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The Engineer

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THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

THE UNIVERSITY OF SHEFFIELD

LECTURER IN MECHANICAL ENGINEERING

Applications are invited for an appointment as LECTURER in MECHANICAL ENGINEERING, to begin duties as soon as possible after 30th June. Preference will be given to candidates having qualifications in engineering manufacture and design. Facilities will be provided for research. Salary scale £550 by £50 to £1100, with superannuation provision under F.S.S.U., and family allowance, the initial salary depending on qualifications and experience.

Applications (four copies), including the names and addresses of three referees and, if desired, copies of testimonials, should be sent to the undersigned (from whom further particulars may be obtained) by 17th June, 1953.

A. W. CHAPMAN,
Registrar.

E8813

UNIVERSITY OF BELFAST

LECTURESHIP IN SOIL MECHANICS

The Senate of the Queen's University of Belfast invites applications for a LECTURESHIP in SOIL MECHANICS from 1st October 1953. Salary range £800 by £50 to £1150 with contributory pension rights under the F.S.S.U. Initial placing on the scale will depend on experience and qualifications. Applications should be received by 10th June, 1953.—Particulars from G. R. Cowie, M.A., LL.B., Secretary. E8824

UNIVERSITY OF BELFAST

LECTURESHIP IN CIVIL ENGINEERING

The Senate of the Queen's University of Belfast invites applications for a LECTURESHIP in CIVIL ENGINEERING from 1st October, 1953. A special interest in surveying would be an advantage. Salary range £800 by £50 to £1150 with contributory pension rights under the F.S.S.U. Initial placing on the scale will depend on experience and qualifications. Applications should be received by 20th June, 1953.—Particulars from G. R. Cowie, M.A., LL.B., Secretary. E8825

LINDSEY COUNTY COUNCIL EDUCATION COMMITTEE

SCUNTHORPE TECHNICAL COLLEGE

FULL-TIME APPOINTMENTS

Applications are invited for the following FULL-TIME APPOINTMENTS to commence in September, 1953 :—

1. One Lecturer, for work up to the standard of Higher National Certificate in Mechanical Engineering. Some experience and qualifications in structural engineering would be an advantage. Candidates should preferably possess a Degree in Engineering or its equivalent and experience in industry is desirable.

2. One Assistant, Grade B, for work up to Higher National Certificate standard in Electrical Engineering. Ability to teach electrical installation work will be an advantage. Candidates should preferably possess a Degree in Engineering or its equivalent and experience in industry is desirable.

3. One Assistant, Grade B, for work up to the standard of City and Guilds Final in Machine Shop Engineering. The post will involve general responsibility for the mechanical engineering workshop. Candidates should hold the Full Technological Certificate of the City and Guilds of London Institute in Machine Shop Engineering, Associate Membership of the Institution of Production Engineers or an equivalent qualification. Experience in industry essential.

4. One Assistant, Grade A, for motor engineering and some general subjects, such as workshop calculations, drawing or science. Candidates should hold at least a Full Technological Certificate of the City and Guilds of London Institute and should have experience in industry, together with some teaching experience.

5. One Assistant, Grade A, for general subjects, such as mathematics, science and drawing in craft and National Certificate courses in the Departments of Engineering and Building.

Further particulars and forms of application obtainable on receipt of a stamped, addressed envelope from the Principal, Technical College, Cole Street, Scunthorpe, Lincs. Applications should be returned as early as possible to the above address.

F. J. BIRKBECK,
Director of Education.

E8855

NORTHAMPTON POLYTECHNIC,

LONDON, E.C.1.

INSTRUMENT DEPARTMENT

VACANCY ON FULL-TIME LECTURING STAFF

Applications are invited for vacancy on full-time LECTURING STAFF of Instrument Department, commencing 1st September, 1953.

Candidates should have wide instrument making experience, a knowledge of aircraft or industrial instruments and preferably H.N.C. or equivalent qualification.

Salary in accordance with London Technical Burnham Scale, Grade A, viz., £415 by £18 to £670, with allowance of £60 for graduates or equivalent and up to £54 for training, plus London allowance of £36 (£48 if over 37).

Particulars and form of application from Secretary.

J. E. RICHARDSON,
Ph.D., B.Eng., M.I.E.E.,
Principal

E8788

PUBLIC APPOINTMENTS

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

ACTON TECHNICAL COLLEGE, HIGH STREET, ACTON, W.3.

HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD of the Mechanical Engineering Department, to commence, if possible, by the 1st September, 1953.

Applicants should hold a good Degree in Engineering and have suitable teaching and industrial experience. The work of the Department includes courses for the B.Sc. Engineering Degree, Ordinary and Higher National Certificates, and National Diplomas in Engineering.

The Department is Grade III on the Burnham Technical Scale.

Salary scale £1190 by increments of £25 to £1340 plus London allowance (£36 or £48) per annum.

Full particulars of the post and application forms may be obtained, by sending a stamped, addressed foolscap envelope, to the Chief Education Officer (F/CW/2), 10, Great George Street, Westminster, S.W.1, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

C. E. GURR,
Chief Education Officer and Secretary to the Education Committee. E8849

LANCASHIRE EDUCATION COMMITTEE

TECHNICAL INSTITUTIONS

WIDNES COLLEGE OF FURTHER EDUCATION

ASSISTANT LECTURER, GRADE A

Applications are invited for the following posts :

Required in the Engineering Department in September, an ASSISTANT LECTURER, Grade A, to teach either mechanical engineering or electrical engineering subjects mainly to O.N.C. standard. Qualifications, Degree or equivalent with industrial experience.

Salary, Burnham Technical Scale, £415 by £18 to £670, plus graduate and training allowances. Commencing salary will depend on industrial and teaching experience after the age of 21.

Application form, obtainable from the Borough Education Officer, Education Office, Lugsdale Road, Widnes, should be returned as soon as possible.

A. L. BINNS,
Chief Education Officer.
County Hall, Preston. E8802

MONMOUTHSHIRE EDUCATION COMMITTEE

THE TECHNICAL COLLEGE OF MONMOUTHSHIRE, CRUMLIN

Principal : Dr. T. V. STARKEY, F.Inst.P.

LECTURER

LECTURER to teach electrical engineering subjects to Higher National Certificate standard, together with some mechanical subjects at Ordinary National Certificate level, is required to commence duties on the 1st of September, or as soon as possible afterwards.

Candidates must possess a Degree or equivalent qualification in Electrical Engineering, and have had considerable post-graduate industrial experience, together with teaching experience.

Salary in accordance with the Burnham Technical Report for Lecturers.

Forms of application, obtained from the undersigned, must be returned not later than the 1st July.

C. E. GITTINS,
Director of Education.
County Hall,
Newport, Mon. E8812

THE INSTITUTION OF PRODUCTION ENGINEERS

ASSISTANT SECRETARY (EDUCATION AND TECHNICAL)

The Institution of Production Engineers invites applications for the appointment of ASSISTANT SECRETARY (Education and Technical). The successful candidate will be responsible to the Secretary for the Institution's educational, membership and technical activities.

The following qualifications are desirable :—

(i) University Degree in Engineering or Science or Corporate Membership of a professional Engineering Institution.

(ii) Industrial experience.

(iii) Teaching experience and a knowledge of the administration of further education. Some research experience would also be an advantage.

(iv) Good personality and appearance, coupled with administrative ability.

The appointment will be in London, but considerable travelling in the United Kingdom will be involved. Salary £1300 p.a., although a higher salary would be considered for an outstanding candidate. Contributory pension scheme.—Form of application obtainable from the Secretary, The Institution of Production Engineers, 36, Portman Square, London, W.1. Closing date for applications 12th June, 1953. E1741

PUBLIC APPOINTMENTS

HARRIS INSTITUTE TECHNICAL COLLEGE

PRESTON

ASSISTANT LECTURER IN CIVIL AND MECHANICAL ENGINEERING

Applications are invited for the above post. Candidates should possess a Degree or equivalent qualification and should have had good practical experience. The duties will include teaching in Higher National Certificate courses.

Salary will be in accordance with the Burnham Scale, Grade B.

Forms of application may be obtained from the undersigned, and should be completed and returned within two weeks of the appearance of this advertisement.

T. M. NAYLOR,
Principal.

E8817

HER MAJESTY'S COLONIAL SERVICE

POWER STATION, ADEN

STATION SUPERINTENDENT

Applications are invited for the following post :—STATION SUPERINTENDENT, Power Station, Aden.

Duties are to take charge of the operation and maintenance of a 20,000kW oil-burning steam station. Appointment is permanent and pensionable, but initially on agreement for one tour of 18–24 months. Salary according to experience up to £1250 p.a. In addition, a non-pensionable cost-of-living allowance at present payable at approximately £150 p.a.

Free first-class passages provided for the officer, his wife and up to four children under the age of eighteen. Government quarters, if available, provided at rental of approximately 12 per cent. or 10 per cent. of basic salary. Leave granted at rate of seven days for each completed month of resident service after each tour of service.

Candidates must be A.M.I.Mech.E. and be experienced in the operation and maintenance of turbo-generating and boiler plant at 450 lb./sq. in. and 450 deg. superheat.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE 145/2/01.

E8830

NATIONAL COAL BOARD

SOUTH-WESTERN DIVISION

SITE ENGINEER (ELECTRICAL AND MECHANICAL)

Applications are invited for the post of SITE ENGINEER (Electrical and Mechanical) at a sinking colliery in the No. 9 (Neath) area. The new colliery will be equipped to produce 3000 tons per day.

Applicants should have a sound organising ability and be competent to supervise operations on site. Preference will be given to those having some experience of shaft sinking, and the installation of heavy colliery plant, including winders, fans and compressors.

Dependent upon age, ability and experience, the salary paid will be in the range of £600 to £950 per annum. A house will be available.

Applications, which should contain full particulars of age, experience, qualifications and positions held, should be sent to the Administrative Officer, National Coal Board, No. 9 Area Office, Ammanford, Carm, to reach him not later than ten days after the publication of this advertisement. E8821

MINISTRY OF SUPPLY

TECHNICAL AUTHOR

Ministry of Supply requires TECHNICAL AUTHOR at Chessington to prepare instructional publications for Services on all aspects of aircraft gun, bomb, torpedo sights or airborne navigational instruments, including electronics. Qualifications : British of British parents. Recognised engineering apprenticeship, preferably instrument making ; wide appropriate experience ; sound understanding of inst. principles and design, including gyroscopes and optical systems ; knowledge electronics, experience writing or editing tech. publications ; possession of H.N.C. or equivalent desirable. Salary within £718–£870. Not established, but opportunities to compete for establishment may arise.—Application forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting Ref. C272/53A. Closing date 12th June, 1953. E8806

BRITISH ELECTRICITY AUTHORITY

(SOUTH WEST SCOTLAND DIVISION)

GENERATION ENGINEER (OPERATION)

British Electricity Authority (South West Scotland Division) require a GENERATION ENGINEER (OPERATION). Candidates should preferably be Corporate Members of one or more of the recognised Engineering Institutions and be familiar with the operation of modern H.P. plant. The salary will be within the provisional salary range, £1325–£1800 per annum.

Applications, stating age, present position and salary, and giving full details of qualifications and experience, should be forwarded to D. Moffat, Director of Establishments, British Electricity Authority, Winsley Street, London, W.1, by 15th June, 1953. Quote reference AE/383. E8823

PUBLIC APPOINTMENTS

AIR MINISTRY

WORKS DEPARTMENT

CIVIL ENGINEERS

Air Ministry require CIVIL ENGINEER[S] duty in their Works Department for engi[neering] and administrative work on the construc[tion] maintenance of civil engineering and buildin[g] jects (covering barracks, workshops, runways, [etc.] water supply, sewage, drainage works, [etc.] R.A.F. and civil aviation stations. Appoint[ments] include liability for service overseas and will [be] two grades (a) main grade with starting salary [of] rising by eight annual increments to £[1]250 (b) assistant grade with starting salary at [age] viz., age 25, £628 p.a., rising to £875 at age [30] after rising annually to £970 p.a. Salaries [are] lower in provinces. Appointments are [temporary] but have long-term possibilities. A special [allowance] of up to £1300 a year, according to location, [is] able in addition to salary during overseas [service] Candidates must be natural-born British subjects in the case of Civil Engineers (main grade) [or] Corporate Members of the Institution of Civil [Engi]neers or Institution of Municipal Engineers. Degree in Civil Engineering would be an advan[tage] In the case of Assistant Civil Engineers an appl[icant] should hold one of the following qualifications B.Sc. (Eng.) or equivalent, A.M.I.C.E., or A[.]Mun.E., or Sections A and B of the Institution Civil Engineers or the Testamur of the Institution Municipal Engineers. In addition, they should at least two years' civil engineering experience staff of a Government Department, local auth[ority] or a firm of consulting engineers or contract[ors] good standing. Appointments to locations nearest to those specified by applicants arrang[ed] far as possible.—Application forms, q[uoting] reference E213/53/A in the case of Civil Engi[neers] (main grade) and E50/53/A in the case of Assi[stant] Civil Engineers, may be obtained from the M.L. Technical and Scientific Register (K), Ad[miralty] House, 26, King Street, London, S.W.1. E8

THE COMMONWEALTH RELATIONS OFFICE

COLOMBO PLAN TECHNICAL CO-OPERATION SCHEME

PRINCIPAL OF BHAVSINHJI POLYTECHNIC INSTITUTE, BHAVNA[GAR] (BOMBAY REGION), INDIA

The Commonwealth Relations Office invite[s] applications for the post of PRINCIPAL of Bhav[singhji] Polytechnic Institute, Bhavnagar (Bombay Re[gion] India. Duties : administration of Institute [and] some teaching. Applicants should have [suitable] qualifications in automobile engineering and [gen]eral education.

Duration three years. Salary £1400 p.a. with free allowance of £1410 per annum for a [married] man, £890 if single. Children's allowance if [appro]priate. Free furnished accommodation or allow[ance] in lieu. Free medical attention, free passages appointee and dependants.—Application forms [and] full details from Ministry of Labour and Nat[ional] Service (A.S.12), Almack House, 26, King [Street] S.W.1, quoting A.12/I.84E/53. E[8]

HALIFAX AREA HOSPITALS MANAGEMENT COMMITTEE

GROUP ENGINEER

Applications invited for post of GROUP E[NGI]NEER to be responsible for operation and co-ord[ina]tion of engineering services, including staff of t[he] men for a group of seven hospitals in the Halifax Todmorden areas. Candidates must be appr[en]tice or otherwise suitably trained in mechanical engi[nee]ring with practical experience of boiler plants, [hot] water service, and electrical maintenance [work] Possession of one of the following Certificates essential :—Higher National Diploma or Certi[ficate] in Mechanical Engineering ; Diploma in Mech[anical] Engineering of a recognised technical college ; [or] First-Class or First-Class Certificate of Compet[ency] in Marine Engineering, or equivalent Naval C[ertifi]cate. Post vacant September, 1953. Salary £750 by £25 to £825 by £30 to £855 per an[num] subject to superannuation.—Applications, st[ating] age, training, qualifications and experience, to[gether] with the names and addresses of three persons whom reference may be made, to be forwarded to Group Secretary, Royal Halifax Infirmary, Ha[lifax] by 30th June, 1953. E[8]

SHEFFIELD No. 1 HOSPITAL MANAGEMENT COMMITTEE

FIR VALE INFIRMARY AND CITY GENERAL HOSPITAL

ASSISTANT ENGINEER (NON-RESIDE[NT])

Applications are invited for the appointment [of] ASSISTANT ENGINEER (Non-Resident) at [the] Vale Infirmary and City General Hospital, to [assist] the Hospital Engineer in the maintenance and op[era]tion of the engineering services at the two hospitals

Candidates should possess an Ordinary Nat[ional] Certificate in Mechanical Engineering or an equi[va]lent qualification.

Salary £450 by £15 to £525 per annum.

Apply, giving details of age, qualifications, [experi]ence, &c., with the names of two persons to [whom] reference may be made, to the undersigned at [the] Edge Hospital, Sheffield, 11, not later than 6th [June] 1953.

W. STANSFIELD,
Secretar[y]

E8850

THE ENGINEER

MAY 29, 1953

The Iron and Steel Board

IN the House of Commons on Thursday of last week, the Minister of Supply, Mr. Duncan Sandys, announced that he had made appointments to the Iron and Steel Board in accordance with the provisions of the Iron and Steel Act, 1953. The Minister pointed out that the Act prescribed that the board should be composed of not less than ten and not more than fifteen members. Accordingly, he had appointed eleven members, leaving four places which could be filled if that should be found desirable in the light of the board's experience. Mr. Sandys went on to say that the following had agreed to serve as whole-time members :—Sir Archibald Forbes, independent chairman ; Sir Lincoln Evans, vice-chairman, and Mr. Robert Shone. As it would not be appropriate for a whole-time member of the board to hold any other appointment connected with the iron and steel industry, Sir Lincoln Evans was resigning the general secretaryship of the Iron and Steel Trades Confederation, and Mr. Shone the directorship of the British Iron and Steel Federation. The part-time members, the Minister said, were : Sir Andrew McCance, F.R.S., managing director of Colvilles, Ltd. ; Mr. Neville Rollason, managing director of John Summers and Sons, Ltd. ; Mr. James Owen, general secretary of the National Union of Blastfurnacemen ; Mr. Wilfred Beard, general secretary of the United Patternmakers' Association ; Mr. James Shaw, chairman of Allied Ironfounders, Ltd. ; Mr. Charles Connell, president of the Shipbuilding Conference ; Sir Percy Lister, chairman of R. A. Lister and Co., Ltd., and Mr. G. E. Beharrell, managing director of the Dunlop Rubber Company, Ltd. In reply to a question, the Minister stated that the salaries to be paid were £7500 a year to the chairman, £5000 to the other whole-time members, and £1000 to the part-time members. On Saturday last, it was stated that Mr. Beard had withdrawn his acceptance of office as a part-time member of the Board. The Minister of Supply announced that Mr. Andrew Naesmith, general secretary of the Amalgamated Weavers' Union, had been appointed in his place. Mr. Naesmith, like Mr. Beard, is a member of the general council of the Trades Union Congress.

Institute of Seaweed Research

THE Institute of Seaweed Research has published its annual report for 1952. It records that the year was noteworthy for a significant expansion in the Institute's equipment and facilities, and that all the problems given first priority in the research and development programme were under investigation. Special reference is made in the report to the success of the first International Seaweed Symposium which was held in Edinburgh last July. Throughout the year work was continued on the development of harvesting sublittoral seaweed. Three methods —the intermittent grapnel, the continuous grapnel, and the cutting and entrainment methods —have now been investigated by the Institute, and the report states that the last-mentioned method requires further work on guiding the cut weed to the entrainment inlet before its principle of operation can be considered proved. It may be recalled that articles reviewing the progress made with the harvesting of brown sublittoral seaweeds were published in THE ENGINEER in May, June and July, 1952. In the mechanical engineering section of the Institute, a considerable amount of time has been devoted to repairs to boats and equipment, the conversion of existing accommodation to laboratories, the improvement of workshop facilities, the installation of plant and equipment, and the harvesting of fresh seaweed for semi-technical scale algal chemical process development and large-scale feeding trials. The report mentions that the work on the Institute's boats has included the fitting out, with dual continuous grapnels, of the 51ft prototype harvesting vessel, the " Chondrus." Lord Bilsland is chairman of the Institute's board of management, and the work of the Institute is carried out under the supervision of the director, Dr. F. N. Woodward.

Exhibition of Transport Relics

AN exhibition entitled " London on Wheels " was opened, on Wednesday of last week, at Euston Station, London, by Lord Hurcomb, chairman of the British Transport Commission. The exhibition, which is reminiscent of London travel in the nineteenth century, has been arranged under the direction of Mr. John Scholes, curator of the British Transport Commission's historical relics. An interesting collection of transport material has been assembled, including some of the earliest railway tickets, handbills and posters ; there is a model of London's first horse tram, built in 1861 and named " The People," and there are examples of such items as handcuffs, oil lanterns and truncheons issued to the railway police, as well as of the pistols and blunderbusses carried by guards on mail coaches. The exhibition also includes models of hansom cabs and horse buses, Thames steamers, locomotives and carriages, signals and other railway equipment. Among the locomotive models is one of the G.W.R. " Iron Duke," a broad-gauge engine, which did its first trial run in 1847. Two of the larger exhibits, which have been specially built for the occasion, are a full-scale model of a Midland Railway third-class compartment of 1875 and a model of a Pullman car of about 1895. At the opening of the exhibition, Lord Hurcomb spoke about the work of the Transport Commission's historical records section, and of the hope that at some future date museums for the display of objects associated with British transport would be established in London and in Scotland. It was intended, he said, that the railway museum at York should continue to concentrate on the history of railways in the North of England. The present exhibition, which will continue until August 29th, is arranged in the Shareholders' Meeting Room at Euston Station. This room was specially built in 1849 for general meetings of railway shareholders, and has lately been restored as nearly as possible to its original colouring and appearance.

Retirement of London Transport's Chief Engineer

LONDON TRANSPORT has announced that its chief engineer, Mr. Percy Croom-Johnson, M.I.C.E., will retire on June 20th, after over forty years in the engineering profession, during nearly thirty of which he has been closely associated with passenger transport in London. Mr. Croom-Johnson began his career in 1912 as an assistant engineer to the Liverpool Corporation. After active service with the Royal Artillery in the first world war, he returned to Liverpool, where he was engaged mainly on the construction of roads and tramways and the development of rapid-transit roads. Subsequently, Mr. Croom-Johnson joined a firm of public works contractors in London, and later was appointed by the Ministry of Transport as chief resident engineer on the survey and construction of the Purfleet–Tilbury arterial road. When that work was completed, the Ministry selected him to take charge of the structural alterations to the Menai Bridge. In 1924, Mr. Croom-Johnson joined the staff of the London County Council Tramways as assistant permanent way engineer. A year later he succeeded to the post of permanent way engineer and became responsible for the maintenance, renewal and reconstruction of L.C.C. tramways. When the London Passenger Transport Board was formed in 1933, Mr. Croom-Johnson assumed responsibility for the tracks and buildings taken over from the municipal and company tramway undertakings. He was appointed chief stores superintendent in 1939 and chief engineer (civil) in 1943. In this latter post the work of first-aid repair and restoration of war damage to London Transport rail and road undertakings came under Mr. Croom-Johnson's care, and it was also his responsibility to supervise much of the work entailed in the extension projects which London Transport has completed since the war. Mr. Croom-Johnson was created C.B.E. in 1948.

Incorporated Plant Engineers' Conference

LAST week the annual conference of the Incorporated Plant Engineers was held at Southport, under the presidency of Mr. J. C. Veale, who was elected in place of Mr. J. C. Tremayne, who was unable to take the office owing to illness. In the course of his presidential address Mr. Veale restated the aims of the Association, and outlined its work. He pointed out that it was by management of his men that the engineer-in-charge effected the improvements which his technical skill suggested. The essential attributes for sound management were practical and technical ability and a strong personality. Other qualities equally essential were loyalty, conscientiousness, determination, sincerity, and enthusiasm. In the course of the conference Mr. E. J. Parish presented a paper " Management and the Plant Engineer," and another paper, " The Lubrication of Engines and Industrial Equipment," was read by Dr. C. B. Davies. Two prize papers were also presented at the conference. One of these papers, " Heat Exchangers—Maintenance and Reconditioning," won the first prize of the Alexander Duckham Memorial Award for Mr. G. E. Halter. The other paper, by Mr. G. W. Campbell, was entitled " Transportation," and won the second prize under the award.

Jet Aircraft Noise

A JOINT symposium of the Royal Aeronautical Society and the Acoustics Group of the Physical Society was held on Thursday of last week at the Institution of Mechanical Engineers to discuss aeronautical acoustics with particular reference to jet noise. Amongst the papers submitted for discussion concerned with actual engine noise was one by Mr. Greatrex, of Rolls-Royce, Ltd., which is largely reproduced elsewhere in this issue. Another paper on this subject entitled " Jet Engine Noise," was submitted by Professor E. J. Richards, of Southampton University. The other papers were concerned with the character of aerodynamic noise propagation by sources other than those associated with the jet pipe. A paper by G. M. Lilley, entitled " Aerodynamic Noise," reviewed briefly what is thought to constitute propeller noise, boundary layer noise, and jet noise, and referred extensively to the theory of sound generated aerodynamically as discussed by Lighthill before the Royal Society last year. The particular aspect of noise generated by an aircraft travelling at supersonic speed was introduced at the Symposium by Mr. C. H. E. Warren, of the Royal Aircraft Establishment, who concluded that nothing could be done in design to reduce the noise due to sonic bangs. Ground-to-ground noise was the subject of a paper from Mr. J. D. Hayhurst, of the Ministry of Supply, which was concerned particularly with the suppression of noise associated with the rather prolonged ground running of engines in the maintenance hangars.

Present - Day Locomotive Working in Great Britain

No. VIII—THE THOMPSON AND PEPPERCORN "PACIFICS" OF THE FORMER L.N.E.R.—PART I

By O. S. NOCK, B.Sc., M.I.C.E., M.I.Mech.E.

The day-to-day running of the Gresley "Pacifics" on the L.N.E.R. in the years 1932–39 was an outstanding aspect of British locomotive working before the second world war. Due to maintenance troubles during the war the L.N.E.R. decided not to perpetuate the Gresley front-end in post-war designs. The new locomotives have three separate sets of valve gear, and some performances of both the Thompson and the Peppercorn varieties are described in this article.

AFTER the death of Sir Nigel Gresley, in 1941, Mr. Edward Thompson was appointed Chief Mechanical Engineer of the L.N.E.R. Although there was at that time little prospect of a speedy end to the war the new chief began to formulate plans for the standardisation of the entire locomotive stock of the company, and certain prototype engines, such as the "B1" mixed traffic 4–6–0, were constructed. Following the long-established practice of the Great Western Railway, and the policy developed on the L.M.S.R. during Sir William Stanier's régime, Mr. Thompson decided to use no more than two cylinders on all types except those for the heaviest express passenger and mixed traffic duties. Under the stress of wartime conditions the conjugated valve gear standardised by Sir Nigel Gresley on his three-cylinder "Pacifics" and 2–6–2s had given some trouble, and three separate sets of valve gear have been provided on all "Pacific" engines built since 1942. The first Thompson "Pacifics" were conversions from the Gresley "P2" class 2–8–2s; the leading pair of driving wheels were removed, and a new front end was fitted. As in Churchward's practice on the Great Western, the three cylinders were positioned so that an equal length of connecting-rod could be obtained for both inside and outside cylinders. Although the arrangement could readily be accommodated on the frames of the former 2–8–2 engines, the resulting distance between the rear bogie wheels and the leading pair of coupled wheels (Fig. 1) was unusually long—8ft 2in.

The converted 2–8–2s were the forerunners of three further varieties of Thompson "Pacific," as shown in Table I opposite. Variety No. 3—engine No. 4470, "Great Northern"—was also a conversion from the pioneer Gresley "Pacific" of 1922; it was intended to be the prototype of the new standard express passenger engine. Variety 4 was the only one to be built in any quantity:

Varieties 5 and 6 are the Peppercorn standard locomotives (Fig. 2), on which the distance between the rear bogie wheels and the leading pair of driving wheels is reduced to 5ft 7in. The outside cylinders are positioned between the bogie wheels and the connecting-rods are, in consequence, longer than the rod of the inside cylinder. The boilers were developed from the very successful "Pacific" design of Sir Nigel Gresley, and on the new engines they have given good results. All engines of varieties 1, 4 and 6 are fitted with double blast pipes and chimneys. At first, the Peppercorn engines did not seem very free in their running, but this has since been rectified by some adjustments to the valve setting, and the performance of both "A1" and "A2" classes has now reached a high standard.

The steaming of the "A1" class, in particular, is some of the freest I have ever witnessed on the footplate. In one way this is a disadvantage in that firemen become so used to being able to raise the pressure quickly that some are prone to give less continuous attention to the job than is desirable, and are thus not able to cope with a rough trip so readily as they might otherwise do. On one trip on which the engine was remanned *en route* the second fireman went about things in such a slap-dash way that he very quickly landed his driver in trouble for steam. On other journeys I have seen the firing and the manipulation of the injectors carried out with such attention and care that the engine hardly ever blew off.

At the present time, with no fewer than 202 "Pacific" engines available on the former L.N.E.R. lines, in addition to 184 large 2–6–2 mixed traffic engines of the "Green Arrow" class, a degree of "zoning" has been introduced in the allocation of locomotives to individual sheds. The Gresley streamlined "A4" class are responsible for most of the top link express work from King's Cross and Edinburgh (Haymarket) sheds. The principal duties from Gateshead and Leeds (Copley Hill) are worked by Peppercorn "A1" engines, while north of Edinburgh, on the coastal route to Aberdeen, the Peppercorn "A2" engines are mostly employed. All varieties of the post-Gresley engines seem to possess that turn of speed that has so characterised L.N.E.R. locomotives for many years. Two runs over the fine road between York and Darlington, both with 6ft 2in engines, gave the following results:—

Engine No.	60,539*	60,515†
Engine name	"Bronzino"	"Sun Stream"
Load, tons gross ...	480	480
Direction	Northbound	Southbound
Distance, miles	44·1	44·1
Actual time, start to stop	42 min 51 sec	42 min 22 sec
Net time, min	42½	40
Average speed over 30·3 miles, Aine to Croft	73·5 m.p.h.	73·8 m.p.h.

* Peppercorn type. † Thompson type.

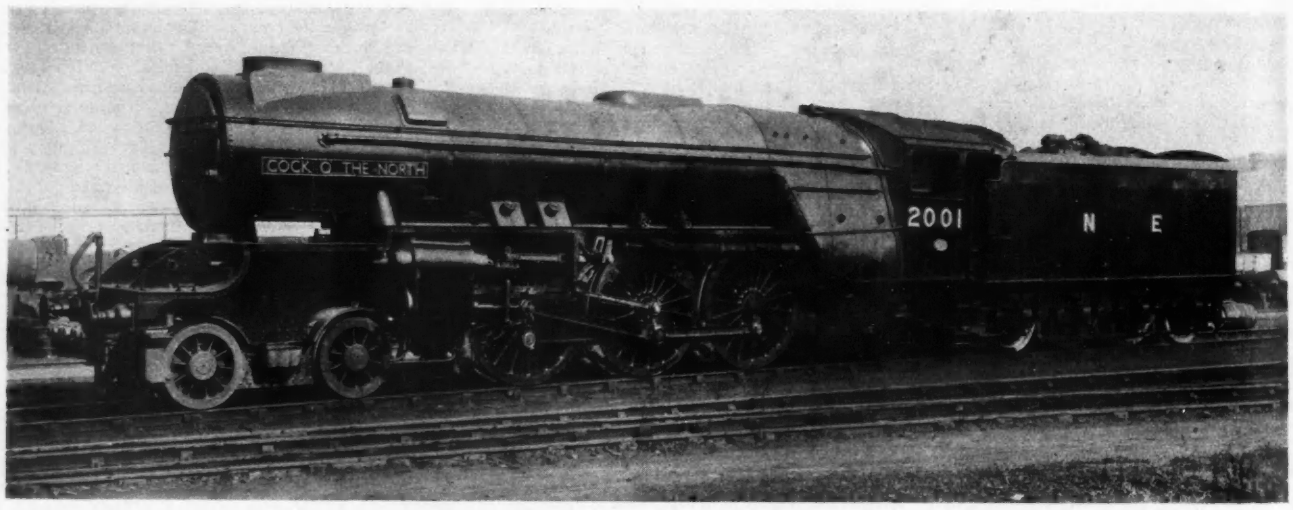


Fig. 1—The "Cock o' the North" Class "A2/2"—Rebuilt from 2-8-2 Class "P2"

On the southbound run engine No. 60515 had reached no more than 54 m.p.h. on passing Croft Spa (2·6 miles) out of Darlington, while on the northbound run the initial and concluding speeds were both 74 m.p.h. No. 60,515 ran 20·6 miles from Thirsk to Skelton Junction at an average speed of 81·8 m.p.h., with a speed of 83 m.p.h. sustained on dead level road.

A fine record of punctuality is being maintained by the "A1" engines on the "Queen of Scots" Pullman train. The following Table II gives skeleton details of runs timed by a number of recorders on this and other trains.

Some of these runs, notably those of No. 60,120, from King's Cross to Leeds, and of No. 60,127, from Newcastle to Edin-

* Previous articles in this series were: No. I, "The L.N.E.R. 2–6–2 'Green Arrow' Class," October 11, 1946; No. II, "The L.M.S.R. 'Coronation' Class 'Pacifics,'" December 13 and 20, 1946; No. III, "The G.W.R. Oil-Fired 4–6–0s," February 6 and 13, 1948; No. IV, "The Mixed Traffic 4–6–0s," November 4, 11, 18 and 25, 1949; No. V, "The Western Region 'Castle' Class," April 20 and 27, 1951; No. VI, "First Results from the 'Britannias'" April 4, 1952; No. VII, "The Gresley 'Pacifics' on the East Coast Route," July 18 and 25, 1952.

burgh, involved quite first-class standards of performance, though so far nothing has come to my notice that definitely surpasses the best standards set up by the Gresley streamlined "A4" engines in pre-war years. The "A1" engines are proving singularly free from troubles, and mileages of 130,000 between general overhaul are proving quite common with those engines fitted with roller bearings. The average for the whole class is about 93,000 miles. When first placed in service both "A1" and "A2" classes of Peppercorn design showed a tendency to "hunt," in certain circumstances; this was particularly noticeable on curving stretches of line. But since some modification has been made to the bogie springing arrangements this tendency appears, from my recent footplate experiences, to have been eliminated.

From my total footplate mileage on various post-Gresley "Pacifics" I have chosen those given in Table III for special reference.

These runs collectively cover almost every class of work now set to these locomotives excepting the Pullman non-stops between King's Cross and Leeds. For the greater part of the year, however, the "Queen of Scots" express loads to no more than nine cars, or about 370 tons with passengers and luggage. On the other hand, as shown by the run of engine No. 60,119 in Table II, drivers put the power at their disposal to good effect in the regaining of lost time, on what would ordinarily be regarded as a fairly easy schedule—185·8 miles non-stop at a booked average speed of 53·1 m.p.h.

TABLE I

Ref. No.	Class	Coupled wheel dia., ft in	Cylinders, dia./str.	Boiler pressure, lb per sq in	Grate area, sq ft	Nominal tractive effort, lb	Number of engines built
1	"A2/2"	6 2	20×26	225	50	40,320	6
2	"A2/1"	6 2	19×26	225	41½	36,385	4
3	"A1/1"	6 8	19×26	250	41½	37,400	1
4	"A2/3"	6 2	19×26	250	50	40,430	15
5	"A2"	6 2	19×26	250	50	40,430	15
6	"A1"	6 8	19×26	250	50	37,400	49

TABLE II

Route	Engine No.	Name	Load, tons gross	Length of trip, miles	Booked time, min	Actual time, min	Net time, min	Net average speed, m.p.h.
King's Cross-Leeds ...	60,139	"Sea Eagle" ...	415	185·8	205	199½	190	58·6
King's Cross-Leeds ...	60,119	"Patrick Stirling"	370	185·8	210	204	185	60·2
Edinburgh-Newcastle	60,142	"Edward Fletcher"	490	124·4	149	140½	137½	54·3
Edinburgh-Newcastle	60,159	"Bonnie Dundee"	335	124·4	137	138½	130½	57·1
Edinburgh-Newcastle	60,142	"Edward Fletcher"	490	124·4	149	149½	132½	56·5
Newcastle-Grantham...	60,115	"Meg Merrilies" ...	495	162·8	183	177½	162½	60·0
King's Cross-Leeds ...	60,120	"Kittiwake" ...	445	185·8	210	200½	180½	61·8
Newcastle-Edinburgh	60,127	"Wilson Worsdell"	355	124·4	136	141½	119½	62·5

TABLE III

Class	Engine No.	Name	Route	Load, tons
"A2/2"	60,506	"Wolf of Badenoch" ...	Edinburgh-Aberdeen ...	575
"A2/3"	60,520	"Owen Tudor" ...	Peterborough-York ...	475
"A2"	60,538	"Velocity" ...	Grantham-York ...	500
"A2"	60,525	"A. H. Peppercorn" ...	Aberdeen-Dundee ...	450
"A1/1"	60,113	"Great Northern" ...	King's Cross-Grantham ...	440
"A1"	60,159	"Bonnie Dundee" ...	Carlisle-Symington* ...	365
"A1"	60,142	"Edward Fletcher" ...	Edinburgh-Newcastle ...	440
"A1"	60,147	"North Eastern" ...	Newcastle-Grantham ...	440

* Caledonian route

THE EDINBURGH AND ABERDEEN RUNS

It will be convenient to take the runs of engines 60,506 and 60,525 together. No. 60,506, "Wolf of Badenoch," had an exceptionally heavy train on the down Aberdonian sleeping car express. It was just at the end of the war and the train was packed, compartments, corridors and guards' vans alike. The performance was of particular interest, as the engine had not long been converted from a 2–8–2, with consequent reduction in adhesion weight from 79 tons to 66 tons, and in nominal tractive effort from 43,462 lb to 40,320 lb. The train then had a non-stop run of 59·2 miles from Edinburgh to Dundee, and then there followed relatively short runs of 17·0 13·7 24·5 and 16·2 miles. Excepting the first of these latter, that from Dundee to Arbroath, they lead over steep switchback gradients. To make the test more exacting still we ran into a steady rain north of Dundee, and with the rails slippery the later stages of the run provided an interesting test of enginemanship. The run can be summarised as follows:—

The non-stop run of 59·2 miles from Edinburgh to Dundee includes many permanent speed restrictions: 25 m.p.h. at Inverkeithing, 45 m.p.h. through Aberdour and for about a mile beyond, 25 m.p.h. at Burntisland, and again through Kinghorn Tunnel, 45 m.p.h. at Ladybank Junction, 55 m.p.h. through Cupar and again at Leuchars Junction, while the final slowing for Dundee begins at the south approach to the Tay Bridge. Added to these slacks, which are due to the curvature of the

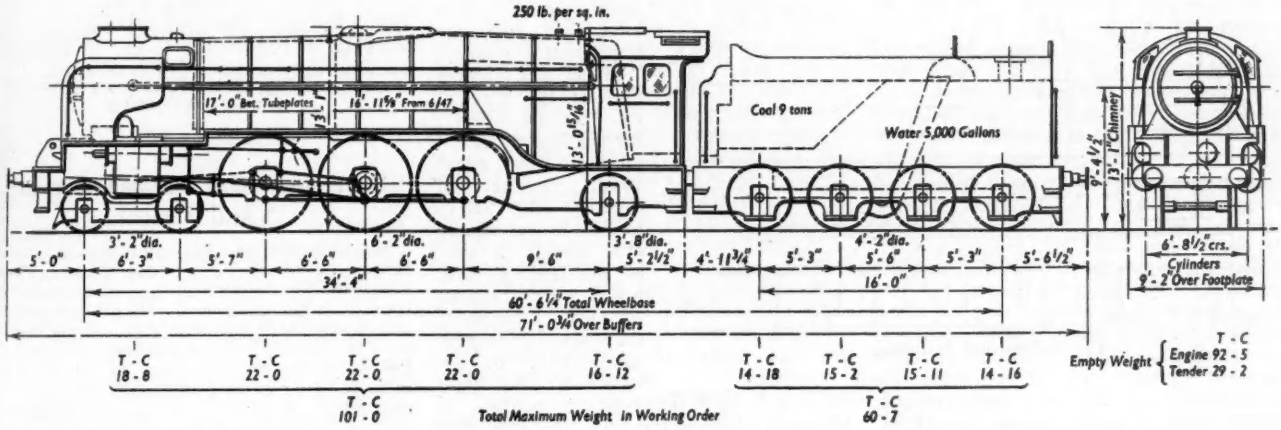


Fig. 2—Class "A2" Locomotive—Peppercorn Design

Boiler:

Maximum diameter of barrel	6ft 5in
Overall length of firebox	11ft 4½in
Overall length of firebox at bottom	7ft 11½in
Overall width of firebox at bottom	7ft 9in
Thickness of barrel plates	⅞in and 1⅛in
Thickness of outside wrapper	⅜in
Thickness of copper firebox plates, wrapper and backplate	½in
Thickness of tube plate	⅝in and 1⅛in

Tubes:

Small:	
Number	121
Diameter outside	2¼in
Superheater flue:	
Number	43
Diameter outside	5¼in
Superheater elements:	
Number	43
Diameter inside	1·244in

Grate:

Area, square feet	50
Heating surface:	
Firebox, square feet	245·3
Tubes, square feet	1211·57
Flues, square feet	1004·5
Total evaporative area, square feet	2461·37
Superheater, square feet	679·67
Total, square feet	3141 04

Safety valves: Type and diameter, two Ross "Pop," 3½in dia.

Axles:

	Dia.	Length
Journals:		
Bogie	6½in	11in
Coupled wheels	9½in	11in
Trailing wheels	6in	11in
Crankpins:		
Outside	6½in	6in
Inside	9½in	6in
Coupling pins:		
Leading	4½in	3½in
Driving	7½in	4½in
Trailing	4½in	5in

Cylinders:

Number	3
Diameter and stroke	19in×26in

Motion:

Type outside	Walschaert
Type inside	Walschaert
Type of valve	Piston
Diameter of valve	10in
Maximum valve travel	6¼in
Steam lap inside cylinder	1¼in
Steam lap outside cylinder	1¼in
Cut-off in full gear	75 per cent
Tractive effort at 85 per cent boiler pressure	40,430 lb
Total adhesive weight	147,840 lb
Adhesive weight ÷ tractive effort	3·67

Brake: steam brake and vacuum ejector

track, there is a pitfall subsidence check at Thornton Junction of exceptional severity. With so many hindrances the recovery of 7 min between Inverkeithing and Dundee on this trip was a most enterprising piece of work, particularly as there is no chance of steaming the engine continuously for any length of time. To give a general impression of the work involved the accompanying diagram (Fig. 3) has been prepared, showing the general profile of the line and the way in which the locomotive was worked. The changes in gradient are very numerous and all details have been omitted from the profile for clarity. Most of the steepest adverse pitches are inclined at about 1 in 100. Against such intermittent demands upon the boiler the steaming was consistently good. There were times when the engine was inclined to slip, but for the most part the response to the driver's handling was excellent. North of Dundee, with the rails wet and no chance of attacking the steeper gradients at any speed, the tendency to slip was a more serious handicap with so heavy a train. As will be seen from the table of summary times (Table IV) some difficulty was found in keeping time north of Dundee, though the load was an extremely heavy one for this stretch of line. Present schedules over this route have been cut to any extent only between Montrose and Stonehaven.

TABLE IV

Miles	Timing points	Schedule, min	Actual, min	Schedule speed, m.p.h.	Actual speed, m.p.h.
0·0	Edinburgh (Waverley)	0	0		
—		—	Signal stop		
13·2	Inverkeithing	19	28½	41·7	27·8
30·7	Thornton Junction	47	55	37·5	39·3
39·1	Ladybank Junction	59	66½	42·0	44·7
50·9	Leuchars Junction	73	78½	50·5	57·0
59·2	Dundee (Tay Bridge)	87	89½	35·5	43·5
17·0	Arbroath	23	23½	44·3	42·9
13·7	Montrose	22	23½	37·4	34·7
24·5	Stonehaven	39	36½	37·7	40·2
16·2	Aberdeen	24	24	40·5	40·5

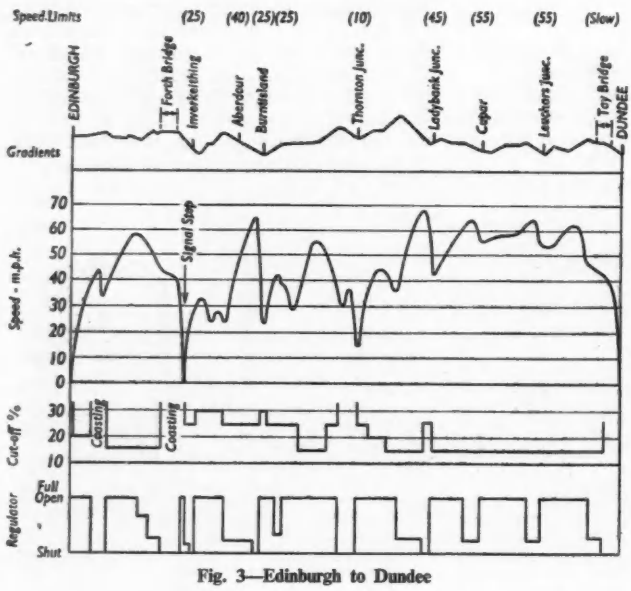


Fig. 3—Edinburgh to Dundee

PEPPERCORN "A2" WORKING

The run on the corresponding southbound express with Peppercorn "A2" "Pacific" No. 60,525, named after the designer, was logged from the footplate by Mr. Ronald I. Nelson, and he has put very complete details at my disposal. The load was a more manageable one of 450 tons all told, and a further advantage was the omission of the Stonehaven stop. Having due regard to the work done and to the driver's remark that the engine "would not run on less than 25 per cent cut-off," it would seem that the reverser scale was showing values about 10 per cent more than was actually the case. From the very detailed record compiled by my friend it is seen that cut-offs indicated as 35 and even 40 per cent were being used, with full regulator, where the resulting performance suggested 25 to 30 per cent. On the level stretch south of Arbroath "25 per cent" with full regulator produced no more than 67 m.p.h. sustained with this 450-ton train.

In starting from Aberdeen, a slack for permanent way repairs alongside Craiginches yard prevented the attainment of the usual good speed of 40 m.p.h. or so before taking the heavy climb on to the cliffs near Cove Bay, and cut-offs indicated as 33 to 38 per cent were necessary to hold a speed of about 33 m.p.h. on the 1 in 100 gradient. The most impressive uphill performance was from Stonehaven up the glen of Carron Water. Over the 5 miles from Stonehaven Viaduct to Carmout the gradient averages 1 in 120; from an initial speed of 70 m.p.h. a fall to nothing less than 47½ m.p.h. was noted, during which time cut-off was advanced, step by step, from a nominal "25 per cent" at the foot of the gradient to "30 per cent" for the last 1½ miles. During this climb steam pressure fell slightly from 250 lb to 235 lb per square inch, though in view of the freedom with which the engine steamed throughout the journey no significance need be attached to this slight fall. The 40·6 miles from Aberdeen to Montrose were covered in 52½ min start to stop, against 56 min booked. This was followed by 20¾ min start to stop over the 13·7 miles from Montrose to Arbroath, and, finally, 21¼ min over the 17 level miles from Arbroath to Dundee. On the downhill stretches speed was at no time allowed to exceed 70 m.p.h. Steam was shut off for considerable periods, with the reverser put into "45 per cent," in which conditions engine and train ran freely at about 65 to 68 m.p.h. on falling gradients.

After the introduction of the Gresley "P2" 2–8–2 engines in regular service on the Aberdeen route, in 1935, through engine workings between Edinburgh and Aberdeen which had been adopted earlier with the "Pacifics" were abandoned for a time, so as to confine the "P2" engines to regular crews at Haymarket shed and Dundee. These through workings were revived generally during the war and extended to all passenger rosters, so that "P2s," "Pacifics" and the "Green Arrow" 2–6–2 worked through, and were remanned at Dundee on every trip. My footplate journey on the "Wolf of Badenoch" was made while this practice was still in operation, though at a later date the changing of engines at Dundee was revived, and it is now the regular practice on most trains. An interesting outcome of railway nationalisation is that the former L.M.S.R. and L.N.E.R. running shed organisations at Ferryhill (Aberdeen) have now been integrated. Top link express drivers now run to both Dundee by the old N.B.R. route or to Perth, by the Caledonian route, using engines of L.N.E.R. or L.M.S.R. origin as the case may be. An East Coast express north of Dundee may be worked by either an ex-L.N.E.R. or ex-L.M.S.R. driver. The L.M.S.R. men have taken readily to the Peppercorn "A2" engines and are keeping excellent time; from detailed records of footplate working it seems that they are less inclined to use a fully opened regulator than the ex-L.N.E.R. men, even on the heaviest gradients.

When slogging away at 30 m.p.h. or so, there seems a good deal to be said for the practice of dropping the lever 8 or 10 per cent below the normal running position, even though it might be possible to shorten the cut-off by using a full regulator opening. With engines having a high mileage since last general overhaul such a method imposes less strain on the motion. It may well be a case for the driver's judgment and it would be unwise to attach undue significance to a tendency that seems to have manifested itself since the reorganisation at Ferryhill. It is, however, an interesting example of the reaction of drivers brought up in a different tradition to locomotives of the generic Doncaster school of design. Later in this series of articles there is an equally interesting case of an ex-L.M.S.R. driver, stationed at Polmadie shed, working a Peppercorn "A1" "Pacific," on a fast duty northwards from Carlisle.

(To be continued)

Synthetic Board Manufacture in South Africa

NEGOTIATIONS for the establishment of a factory by Messrs. Boxes and Shooks, Port Elizabeth, for the manufacture of a synthetic board have been completed. The product, which will be sold under the South African trade name of "Novobord," is an inexpensive material for use in the building trade, in cabinet and furniture manufacture as well as for the panelling and allied industries. In the manufacturing process for this product wood chips and specially prepared shavings are coated with synthetic resin and compressed under heat in such a manner as to produce a "sandwich construction" consisting of two highly polished surfaces of compressed shavings enclosing a core of more lightly compressed wood chips. The board is produced in thicknesses from ⅜in to 1¼in in sheets 9ft by 6ft, and can be used in its natural state or can be painted or veneered without cross-banding. The factory will be in operation by the end of 1953 and will cost £325,000. The plant will be situated on a seven acre site in Deal Party Industrial Township, Port Elizabeth, and is designed to operate twenty-four hours a day to produce 10,000,000 square feet of Novobord per annum. It is anticipated that 25 per cent of the output will be exported. All the raw material will eventually be of South African origin.

Iron and Steel Institute

ANNUAL GENERAL MEETING

No. IV—(*Concluded from page 730, May 22nd*)

THE annual general meeting of the Iron and Steel Institute was concluded on Friday, May 1st. During the morning the following papers were jointly discussed.

TEMPER-BRITTLENESS : A CRITICAL REVIEW OF THE LITERATURE

By B. C. WOODFINE

SYNOPSIS

A critical survey has been made of the published work on temper-brittleness up to 1952. Particular attention has been paid to those papers published since 1944, and it is shown that several of the suggestions concerning temper-brittleness which have been advanced are not supported by the experimental results. The various theories which have been proposed to explain temper-brittleness are summarised, and it is concluded that further experimental work is required to clarify a number of outstanding points relating to its occurrence and development.

SOME ASPECTS OF TEMPER-BRITTLENESS

By B. C. WOODFINE

SYNOPSIS

Several aspects of the occurrence and development of temper-brittleness in low-alloy steels have been investigated, including the development of the embrittlement with time and temperature, the occurrence of the embrittlement in isothermally transformed microstructures, the effect of austenitising treatment, and the effect of the alloying elements aluminium, phosphorus and titanium. The etching attack produced by various reagents in temper brittle steels occurs principally along the previously existing austenite grain boundaries, and consists of a network of grooves. No evidence has been obtained of a grain boundary precipitate.

Brittle fracture in temper-brittle steels has been shown to occur by intergranular failure and not by cleavage. The notched bar impact test has been examined theoretically and an attempt has been made to relate it to the fundamental flow and fracture properties of the steels. From the proposed relationship it was predicted that temper-brittleness lowered the brittle fracture strength of a susceptible steel without affecting the yield stress, and this has been confirmed by low-temperature tensile tests. A theory is suggested to explain the occurrence of temper-brittleness.

TEMPER-BRITTLENESS IN HIGH-PURITY IRON-BASE ALLOYS

By A. PREECE and R. D. CARTER

SYNOPSIS

The effect of composition on the occurrence of temper-brittleness has been examined by microscopical methods and measurement of transition temperatures.

By the criteria of rise in transition temperature and development of an intercrystalline brittle fracture after treatment at 500 deg. Cent., Fe-C and Fe-C-P alloys were not found to be susceptible to temper-brittleness, but Fe-Cr-C-P and Fe-Mn-C-P alloys were highly susceptible. Reduction of carbon content to about 0·003 per cent eliminated the embrittling change. Phosphorus was found to have a large and real effect in increasing susceptibility, but its presence may not be essential for the occurrence of temper-brittleness. Addition of nickel to alloys containing manganese or chromium appeared to increase the susceptibility, as judged by rise in transition temperature, but its effect is probably not one of direct increase in the extent of the embrittling change.

Picric acid etchants readily revealed the embrittling change at grain boundaries and sub-boundaries, but only in susceptible alloys that contained chromium.

EFFECT OF ARSENIC AND ANTIMONY ON TEMPER-BRITTLENESS

By G. W. AUSTIN, A. R. ENTWISLE and G. C. SMITH

SYNOPSIS

The susceptibility of nickel-chrome steels to temper-brittleness is slightly increased by arsenic and greatly increased by antimony. Arsenic in the range 0·2 per cent to 0·02 per cent has little effect on the tensile properties at room temperature, but the effect of antimony in the range 0·08 per cent to 0·005 per cent depends upon the precise heat-treatment given to the steel.

The tensile properties of the steels in liquid nitrogen can be correlated with their notched bar impact properties, the correlations being based on Orowan's theory of notch brittleness. Severely embrittled specimens fail in tension with little ductility, the fracture being intergranular (with respect to the prior austenite grains).

DISCUSSION

Dr. N. P. Allen (National Physical Laboratory): With regard to the summary paper by Woodfine, I agree with him in the great importance which he attaches to the paper by Jolivet and Vidal, which was an eloquent demonstration of the points he has made, but he does less than justice to the work of Greaves and Jones when he says that they did not realise that the temper-brittleness phenomenon was essentially a matter of the lowering of the transition temperature. All the authors agree that the raising of the temperature on transition in the impact test is essentially due to a lowering of the brittle strength of the metal, and two of them have confirmed that that is the case by means of low temperature tests. All the authors agree that this is due to the appearance of a grain boundary fracture. At the National Physical Laboratory we have confirmed that these three things are associated with each other in other cases. In our work on pure iron with additions of nitrogen, oxygen and phosphorus we have found the reason for the impact condition temperature resulting in a lowering of the brittle strength. It appears to be rather general.

That leads one to want to know what the actual brittle strengths are. Here I want to admonish rather mildly the two authors, who introduced rather mathematical developments. It is clear, for example, that if you know the temperature variation of the yield point and the fracture stress you can in theory calculate the change in brittle strength from the change of impact transition temperature, but two authors have made a rather inexcusable mistake in that, not knowing what the brittle strength was, they lifted some equations out of the air. Neither of the equations had any foundation in this case. We do not know how to measure these rupture strengths, and one of the most important experimental problems is to find a way of measuring the rupture strength of ordinary materials on ordinary factors. Experimentally, that involves finding some way of postponing plastic deformation until brittleness is reached. It can be done by some experimental device which does not alter the brittle strength.

I regard the whole problem of temper-brittleness from this point of view. You no longer feel inclined to look for a single cause any more than you are inclined to look for a single cause of the proof stress of metal. It is a characteristic which is varied by a great many factors, and the study of the subject involves the list of the factors which affect the result. The factors are partly of composition and partly of heat treatment. The paper by Preece is particularly useful in drawing attention to the very dangerous nature from this point of view of the combination of phosphorus and manganese and the combination of phosphorus and chromium, which has been suspected but not demonstrated so clearly as Preece has done it. The demonstrations with regard to arsenic and antimony are equally valuable, but there are also a great many factors in heat treatment which are not fully realised. First, there is the question of the solidification rate. That appears to affect, in some unknown way, the value of the fracture stress of the material. I am reminded of experiences during the war when failure occurred of tank armour under unexpected conditions. It was found to be due to the fact that the metal was a casting of bad composition and that the metal would have been free from temper-brittleness had it been forged. That has been a point to be looked into. Another point is the very important factor of the conditions of transformation of the steel. At the National Physical Laboratory we have an investigation bearing on that. We are studying the impact transition temperatures as a function of the way in which the material transforms from austenite to whatever it transforms to. We have found that both the strength of the materials when they are tested under the brittle conditions at low temperatures and the impact conditions are affected by the precise manner of transformation.

The temper-brittleness phenomenon is a manifestation of the effects resulting from the quenching of material to temperatures about 500 deg. or so over various lengths of time. At the National Physical Laboratory we have put these things together to establish the view that a relating factor is the opportunity for the segregation of impurities to take place from one part of the metal to another in the course of the heat treatment. But we have recently come across an interesting case which has thrown us back on our haunches. We have found some cases where the material which is cooled most quickly, and therefore has presumably had the least opportunity for segregation of the impurities, is the material which is the most brittle and has the inferior properties at low temperatures. We have not quite sorted that out, but I am sure that interesting things would arise if these points were followed up.

Mr. J. E. Russell (English Steel Corporation, Ltd.) : I propose to put, very tentatively, two further theories on temper-brittleness, making Mr. Woodfine's list of eight up to ten. The first thing that strikes anyone on looking at Woodfine's most beautiful electron microscope pictures is : are these grooves cracks? Would it be possible for these regions to be regions of high-tensile stress which have been set up by unequal attraction of the pre-existing austenite zones during the slow cooling ? Obviously, you will not get absolutely uniform attaction over the whole mass. There will be certain crystallographic directions which will give different coefficients of expansion and you will tend to get crystals pulling apart from each other. That might occur on slow cooling. On fast cooling, however, you could get compressive stresses set up in the inside of the material which would counteract the building up of those high-tensile stresses and, consequently, lead you to a more tough behaviour. Reheating an embrittled material would tend to relieve these micro-stresses and allow the blocks to come apart. Moreover, the speed effect in the tensile and Izod tests would suffice to explain why you did not get the effect showing up on the tensile test because, that being a slow test, the material would tend to yield in the crystals instead of before coming apart at the grain boundaries. That is one possibility which " hits the commentator's eye " looking at the microphotographs.

Coming on to the other theory, of the segregation at the grain boundary, the thing that has always worried me about that theory is that you have to postulate that the

material which segregates at the pre-austenite grain boundaries must be able to move away from the grain boundaries at temperatures of about 650 deg. and to the grain boundaries at temperatures about the embrittling range (temperatures about 550 deg.) and must be able to do that cyclically. You can embrittle and toughen and so forth indefinitely more or less, so this material must be able to migrate to and from the grain boundaries more or less at will. I have always felt that to be somewhat of a difficulty, to say the least. There may be further work on the grain boundary segregation of which I am not aware which may explain that. Some time ago, Cohen, who has done so much work on the austenite to martensite transformation, in some work on the stabilisation of austenite showed that he could get a certain effect on the stabilisation phenomena by varying his "austenitising" conditions, and he postulated in this paper that the austenite was, so to speak, preparing itself for transformation and the closer you got to the transformation temperature the better was it prepared. It is a rather crude sort of explanation, of course. So far as I know, that has not been explained on grain boundary segregation. I was wondering if a similar effect might be occurring in this case, something of an ordered disorder arrangement, that at about 650 deg. you may have got complete disorder of your alloying atoms and as your temperature drops the atoms gradually become more and more ordered and the growth of the order implies an embrittling of the material.

Dr. S. A. Main (Hadfields, Ltd.): We all know that austenite, at temperatures below its stable range, can change into martensite or what will become martensite if it is allowed to remain intact down to ordinary atmospheric temperature. We know, too, that martensite in its turn can break down into one of the forms of ferrite plus carbide, such as sorbite or troostite. But is it appreciated what happens when these two transformations go on simultaneously and continuously?

With reference to the breakdown of austenite, cannot we fairly assume that the carbon in the austenite if it has been properly formed—that is, it has had sufficient time for its formation—is extremely well diffused in solution, in fact, in a more or less atomic but not molecular state? That being so, it would appear in the martensite at the incidence of its production, in that very highly subdivided form which chemists might call a nascent condition, and so in a very highly active chemical condition ready to combine with the iron or other carbide-forming elements. Naturally, such activity will depend among other things on the mobility of the atoms, which will naturally become more and more restricted as temperatures approach atmospheric. It is possible that that point has not been borne in mind, and I think it should be.

Mr. D. McLean (National Physical Laboratory): Temper-brittleness is one aspect of the problem of the tough-brittle transition which occurs in all ferritic materials which have been suitably tested. It is that aspect concerned with the influence of heat treatment and composition on the transition temperature. There are many complicated factors involved, things such as the variation of particle size of carbide, the variation of grain size. In speaking of a cause or theory one seeks for the general underlying cause that is always present. There are two main rival theories, the precipitate one and the segregate one. The best evidence at present is the evidence provided by the electron microscope, particularly Mr. Woodfine's Fig. 8. This micrograph at ×7000 after 128 hours at 575 deg. shows no visible coalescence in the grain boundary grooves, as he points out. Yet the same steel shows quite marked embrittlement after only fifteen minutes at this temperature.

(Here Mr. McLean showed a number of slides.)

The temper-brittle phenomenon extends mainly over the ferritic region, so I turn now to discuss the element or elements responsible. Discussing it in terms of segregation, an interstitial element is likely to be the cause. That only a few elements are responsible is, I think, indicated by the fact that the damaging temperature in so many steels—that is to say, the temperature which produces a rather strong embrittlement in a given time—is in the neighbourhood of 500 deg. over a very wide range of composition, suggesting that not very many different things in all these different compositions are involved. One, therefore, turns to carbon and nitrogen, which are ever-present in steel. At first sight, the results obtained by Preece and Carter with carburised samples appear to support this, but there are complications which make it rather questionable whether one can or cannot draw this conclusion. On the other hand, the result of some work on their plain carbon steels 31, in Table I, where they obtained a negligible variation between tough and brittle transition temperatures, suggests that carbon alone does not produce the effect, and Jaffe and Buffum some years ago found the same thing. It is well known that in plain carbon material containing about a tenth of a per cent of carbon, quench ageing occurs after quenching from 600 deg., which was the treatment applied by these authors to produce their tough condition, and this ageing embrittles the material considerably. Jaffe and Buffum did not guard against this complication. Preece and Carter did not say whether they did or not. If not, this embrittlement will have occurred and will have raised the transition temperature which they would otherwise have got through their tough condition. Consequently, since the tough specimen had about the same transition temperature as the brittle specimen one can conclude that if this complication were avoided it would have a lower transition temperature and that the temper-brittle effect is there.

Mr. A. L. Carr (Mond Nickel Company, Ltd.): Many of the present investigators have embrittled their specimens isothermally because, in this way, the embrittling reaction may be controlled more closely than during continuous cooling from the tempering temperature. In addition, they have determined the impact transition temperatures of their steels and assessed the degree of embrittlement by the shift of transition temperature, although different criteria have been used by the different workers to assess transition temperatures. In my own work I have used 10mm square Izod "V"-notch impact specimens tested in a Charpy machine, and prefer to use the same criterion for transition temperature as Mr. Woodfine, namely, the lowest temperature at which one gets a 100 per cent fibrous fracture.

Mr. A. N. Sage (British Iron and Steel Research Association): The results given in the experimental papers provide us with a feast of information, but, like many feasts, it is best sprinkled with a little salt. This particularly applies to the transition curves which have been reported. Considerable scatter is reported by Preece and Carter in their paper, and I think alternative curves could have been drawn through the points given. This would have an influence on the amount of embrittlement reported. It is also a further point that this would also influence the results provided by Dr. Entwisle, and it is most unfortunate that in that paper no transition curves are actually given. A further point concerning the transition curves in this work is that apparently they have all been obtained as a result of single impact tests at a given temperature. One wonders how significant they are in view of the unsatisfactory nature of the impact test.

Mr. B. L. Hopkins (National Physical Laboratory): In the paper by Austin and his colleagues, when they discuss segregation to grain boundaries they give the impression of having scratched their heads to find other examples of a connection between molybdenum and phosphorus and have quoted the effect of molybdenum in decreasing segregation with manganese steels. In the alloy field there is an example. It is known that phosphorus interferes with the production of an intermediate structure in cast iron on continuous cooling. There was a paper in the American Society of Metals about 1945 in which Rowton and Wood showed that this was due to the segregating effect of phosphiding in relation to molybdenum.

At the final session of the meeting, on Friday afternoon, the following papers were presented for joint discussion :—

THE FORMATION OF BAINITE

By T. Ko and S. A. Cottrell

Synopsis

When bainite is formed from austenite, the specimen surface is distorted, giving a structure similar to that obtained during the formation of martensite. By studying the surface relief during the formation of bainite, using a specially developed metallographic technique and hot-stage microscopy, it has been established that bainite forms by nucleation and slow coherent growth, the rate of which depends on the composition of the austenite and the temperature of transformation. A new theory of the mechanism of bainite formation is proposed. It is suggested that owing to the insufficiency of the driving force, martensite cannot form, and the coherent growth is possible only if the driving force is increased and the strain due to the density change is reduced by lowering the carbon in solution in the bainite. This takes place by diffusion of carbon into the surrounding austenite or by precipitation of carbide within the bainite, or by a combination of both; the rate of growth is therefore controlled by the rate of carbon removal.

EFFECTS OF HIGH-TEMPERATURE HEATING ON THE ISOTHERMAL FORMATION OF BAINITE

By S. A. Cottrell and T. Ko

Synopsis

The effects of high-temperature heating on the rate of the austenite-bainite transformation in En 17, 18, 19, 21, 25 and 31 steels have been investigated. The incubation period is shortened and the rate of transformation is increased in Ni-Cr-Mo steels after austenitising at high temperature. The effect can be removed by re-austenitising at a lower temperature. These effects were not found in the other steels.

THERMAL STABILISATION OF AUSTENITE IN CARBURISING STEELS

By H. M. Otte and T. Ko

Synopsis

A study has been made of the retained austenite in two carburised steels. Ageing at room temperature causes stabilisation of austenite in a carburised Krupp steel, but the effect can be removed by sufficient further cooling.

LINE-BROADENING OF MARTENSITE IN NICKEL STEELS

By R. A. Smith

Synopsis

The X-ray diffraction-line shapes obtained from quenched medium and low-carbon nickel steels have been recorded in a Geiger counter spectrometer. Fourier analysis has been used to determine the true physical broadening from the observed line shapes of the martensite and of annealed iron which is assumed to exhibit experimental broadening only. Further information on the nature of the transformed

material is obtained from a consideration of the Fourier coefficients themselves.

The results indicate that the effects produced by martensitic transformation are similar to those obtained in cold-worked metals. Earlier work is substantiated in that the major part of the line-broadening is due to internal stresses, but the results indicate the presence of a particle-size effect. The carbon content is effective in determining the degree of internal strain remaining after transformation.

THE DEFORMATION OF AUSTENITE IN RELATION TO THE HARDNESS CHARACTERISTICS OF STEEL

By G. R. Bish and H. O'Neill

Synopsis

The pyramid hardness of a 0·9 per cent carbon steel during isothermal transformation at two temperatures just above the M_s line has been determined. The same steel was plastically deformed by crushing during the incubation period of isothermal transformation at these two temperatures. For various amounts of deformation and increasing holding times in the isothermal bath, the hardness at room temperature of the quenched products has been determined by Meyer analysis. Deformation accelerates transformation, and the Meyer index n passes through a maximum with increasing holding times. The maximum occurs at shorter holding times as the amount of deformation is increased. The hardness and strain-hardening properties of various products of heat treatment have been reviewed and a complete hardness diagram for the Fe-Fe_3C system is given in an appendix.

Discussion

Mr. P. Samuel (Hadfields, Ltd.): In the paper on the formation of bainite and Dr. Ko's presentation, I was impressed by the excellent micrographs and the convincing film produced by vacuum etching and hot stage microscopy. With reference to these, and especially to the latter, I wonder if the authors have any explanation to offer for the tramline etching effect of the grain boundaries especially noticeable in Fig. 7 of En 31. The production of grain boundary grooves by vacuum etching is well understood, but there appears to be a suggestion of ridging at either side of the boundaries. Similar effects have been observed in "Armco" iron, and I am wondering whether it might be due to any alteration in the transformation characteristics brought about by the chaotic state of the lattice close to the grain boundary region or to some other mechanism. I should like to know if the appearance is genuine and not just artificial. In the same series of micrographs showing the growth of bainite plates it seemed to me that the rate of growth along the habit planes could be used to calculate the activation energy of the process and further substantiate the authors' theory. A rough calculation gives an activation energy of 36,000 cals./gm. at., which corresponds to that of the diffusion of carbon in austenite. Obviously, if this is the case, the process is not controlled by the diffusion of carbon in ferrite and does not apply to the thickening of the plates, which latter is more likely to be controlled, as the authors indicate, by carbide formation.

With regard to the second paper, on high-temperature effects, I think the authors have made a valuable point in bringing out the effect of austenitising temperature on the shape of the isothermal transformation curve. In En 25 they show the marked difference in shape for 835 deg. and 950 deg. Cent. austenitising temperatures, thus emphasising the dangers of applying a standard transformation diagram to material which has not been austenitised at exactly the quoted temperature of the diagram. I am unable to appreciate, however, why, if the phenomenon is not general, an explanation based on sulphide inclusions is plausible. Surely such inclusions are not confined to Ni-Cr-Mo steels? Perhaps we might invoke the previous paper where it is pointed out that carbide-forming elements hinder the carbon mobility, hence the growth of bainite. If these carbon-attracting elements outbalance the tendency for bainite growth, then transformation will be slow. High-temperature heating will tend to homogenise the structure and weaken the hindrance of carbide-formers, allowing a faster transformation. This could be easily tested by a study of the effect of time at austenitising temperature upon the transformation rate. Has anything been done along those lines? Looking at the results, one wonders whether the molybdenum content itself might not be the decisive factor.

Mr. K. R. Jastrezebshi (Quasi-Arc Company, Ltd.): I wish to confine myself to the paper given by Mr. Bish and Professor O'Neill. The work hardening of 18/8 stainless steel is worthy of study, especially the products of subsequent heat-treatment. At one time I was given some stainless steel wire for examination. It was readily attracted by a hand magnet, and its Vickers hardness number was 523. Although there was some suspicion that it might be the martensitic type, a chemical analysis confirmed it to be of unstabilised 18/8 quality, and the microstructure, when etched with Kalling's reagent, consisted of pseudo-martensite, which was rather pronounced. I tried to obtain information regarding the amount of cold work caused by the drawing operation, but was unable to do so. However, I have calculated the M_s temperature to be about −168 deg. Cent., and this figure, although only approximate, may indicate that the composition of this steel would be suitable for formation of martensite when plastically deformed.

Recently I was confronted with two fillet welds made on ¼in thick plate of En 100 quality steel. In one case a ferritic type of electrode known for its low hydrogen content was used. In the other case a fillet weld was made using nickel-chromium austenitic armour welding electrodes. The welding current, the gauge of the electrodes, the geometry and size of the joints were identical in both cases. The heat-affected areas, being of the same size, indicated that the heat input into the joints could not have varied greatly. Microscopical examination carried out previously showed the parent material to be free from any segregation. The fillet welds were then sectioned, polished and subjected to a hardness survey using a Vickers machine with a 10kg load. The Vickers hardness number of the heat-affected zone produced by the ferritic weld and taken 2mm from the interface was 442. The Vickers hardness number of the heat-affected zone produced by the austenitic weld was 536, giving a difference of 94 V.P.N. These specimens were then heated for one hour at a temperature of 840 deg. Cent. and oil-quenched. The Vickers pyramid numbers were determined at points 2mm away from the weld-parent metal interface. They were 480 V.P.N. near the ferritic weld and 532 V.P.N. near the austenitic weld, giving a difference of 52 V.P.N. All the hardness indentations and micro-examinations were made on the bottom component of the fillet. The difference of 52 V.P.N. is appreciably smaller than that of 94 V.P.N. obtained previously with the specimens in the as-welded condition. This might possibly be accounted for by the fact that an oil-quench is much more severe than that occurring during the welding operation when the specimens are small.

Mr. G. Mayer (The Mond Nickel Company, Ltd.): I have recently made an examination of the formation of bainite in an En 23 steel and I find myself in general agreement with the views expressed by Dr. Ko and Cottrell on the mode of formation of bainite. Their hot-stage microscope results have provided a convincing answer to the question whether the bainite reaction proceeds by nucleation and growth or whether the plates are fully formed in a very short time as in the case of martensite. One difficulty with the latter theory was that while lower bainite has the acicular form associated with the shear type of reaction, upper bainite is not usually acicular, except in the early stages of formation, and it seemed that two different mechanisms of formation would have to exist to explain the difference in appearance of the two types of bainite. This seemed unlikely, particularly since no sharp change in transformation characteristics could be detected with decreasing temperature of bainite formation. From my own studies I have formed the impression that the mechanism of bainite formation is the same at all temperatures, with the bainite tending to form as plates by growth along preferred planes.

Dr. T. Ko (Birmingham University): I should like to make one remark about the paper by Bish and O'Neill. O'Neill has referred to Rostoker's results, which claims that the Meyer index in respect of martensitic steel, using diamond pyramid indentation, gave a result which was very difficult to explain. I am glad to report that Rostoker's experiment has been repeated by Dr. Otto in our laboratories before he left the country. We used the same specimen as that on which Rostoker carried out his experiment, and the new result agreed with the figure given according to the Meyer index, which agrees with the figure quoted by Professor O'Neill and his colleagues—that is to say, the Meyer index determination of martensitic steel, using micro-hardness testing, is 2·0 and not greater than 2·0, as claimed by Rostoker.

Dr. M. L. Becker (British Iron and Steel Research Association): I should like to ask Dr. Ko a question. Supposing we had an austenite with a carbon concentration—we could probably get it up to 1·8 per cent—would the precipitate in the lower bainite region still be ferrite, or would it be very difficult for him to say? It seems to me that, with all the carbon present in that austenite, even if ferrite is the first precipitate, you must almost at once have a change over to carbide and it might be difficult to see from the micro-structure which came first.

Dr. J. Nutting and Mr. A. P. Miodownik also contributed to the discussion. The authors then made brief replies and the meeting ended.

Book of Reference

Ship and Boat Builder Annual Review, 1953. London: John Trundell (Publishers), Ltd., Temple Chambers, Temple Avenue, E.C.4. Price 30s.—This year's edition of the *Ship and Boat Builder Annual Review* follows the same pattern as the 1952 edition, but has been brought up to date and includes many additions to the various directories. These refer to certain sections of the boat-building industry, including a list of builders and repair yards, which is repeated in the form of a geographical index and a list of overseas boat builders subdivided into individual countries. Specifications of main, auxiliary and outboard engines are given and a materials, fittings and equipment section provides information concerning timber, light metal, paint and includes directories relating to the suppliers of marine fittings and yard equipment and materials. There is a directory of consultants, a list of associations and of British owners of small craft, and other sections deal with dock and harbour authorities, commercial diplomatic officers and trade commissioners, and British Chambers of Commerce. In addition to the directories, the annual review contains a number of short articles dealing with various aspects of the industry, including the coastal tanker, diesel engines in Admiralty vessels, the use of plastics, a survey of the smaller craft of 1952, light alloy craft on tropical service, radio navigational aids, and equipment developments.

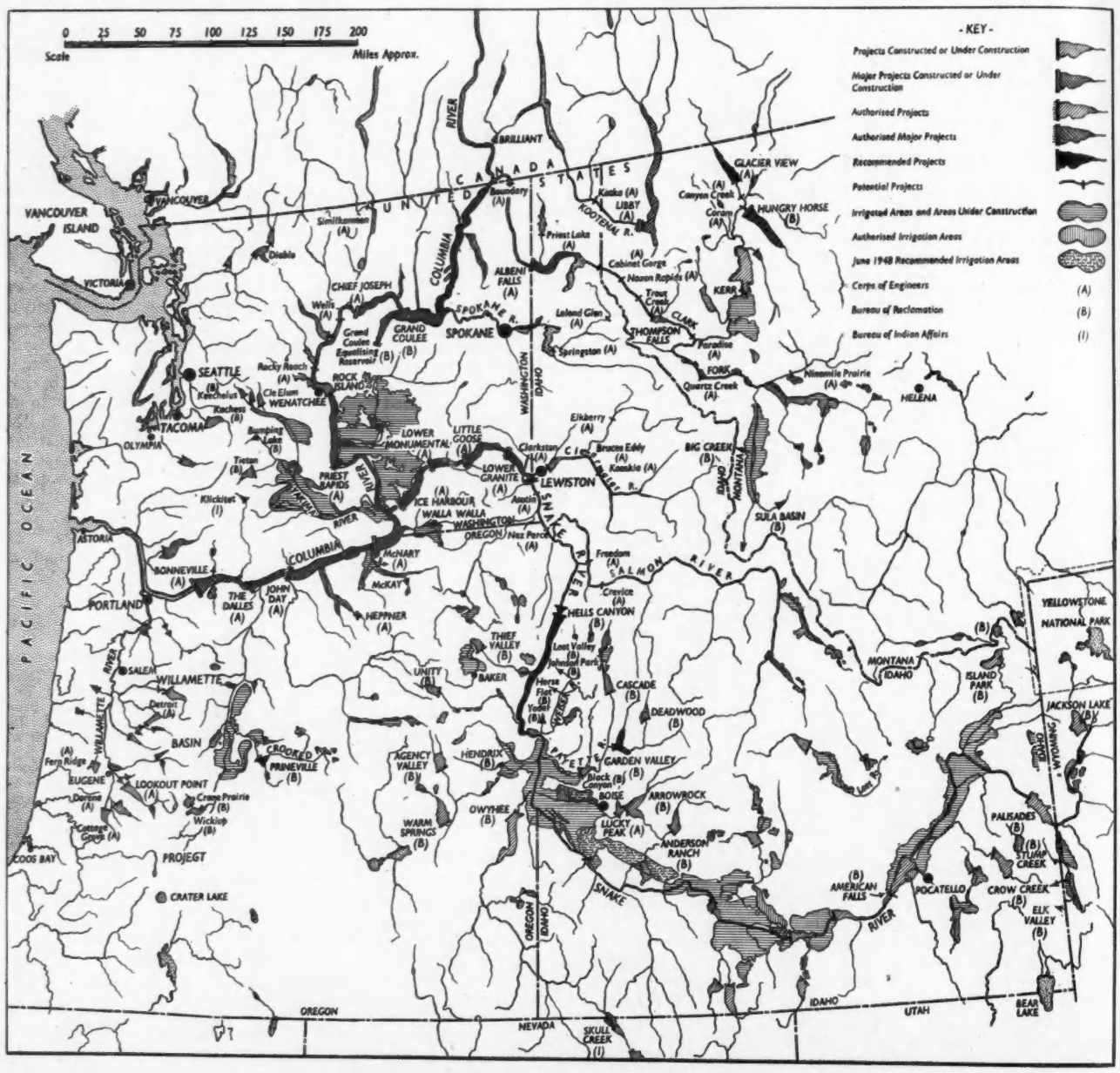
Development of the Columbia River Basin

(*By Our American Correspondent*)

A comprehensive development of the natural resources of the Pacific North West of the United States has recently been proposed. The development plans are based on a five-stage programme for the progressive, multi-purpose utilisation of the waters of the Columbia River catchment.

AN important report outlining a development scheme for the natural resources of the Pacific North-West of the United States was published recently by the Columbia Basin Inter-Agency Committee. This committee was established in 1946 to help in the planning, construction and operation of works for the control and use of the waters of the Columbia River and its tributaries. The Pacific North-West of the United States is a rich and growing region. Its 280,000 square miles contain about 9 per cent of the country's land area, and 3 per cent of its population. The region has the largest hydro-electric power output and 40 per cent of all potential hydro-electric power in America. It is rich in mineral resources and produces 45 per cent of the primary aluminium, 20 per cent of the lead, 18 per cent of the zinc, and 10 per cent of the copper output of the United States. Although possessing the greatest hydro-electric power potential, the region now has the most severe power shortage in the country ; normal growth alone will increase the power demands of the area by 300MW to 400MW each year. The need for an accelerated development of water and land resources is to-day probably more pressing in the Pacific North-West than in any other section of the country, because of its rapid population growth, its lack of low-cost fuels, its high dependence on irrigated agriculture and forest products industries, and the relative under-development of other manufacturing industries in the area.

The basis of the comprehensive plan which has now been published, is a long-term programme for the control and development of the water resources of the Columbia Basin and the Pacific North-West region, including a main water control plan for the Columbia Basin consisting of multiple-purpose dams and reservoirs on the Columbia River and its tributaries, embankments on the lower river, and channel improvement works. Ultimately, an integral chain of projects is contemplated, extending from the headwaters in Western Montana and Western Wyoming, through Idaho, Washington, and Oregon to the Pacific Ocean. The regular and predictable pattern of stream flow in the Columbia River system, with high and sustained snow-melt flow occurring regularly in late spring and early summer, is exceptionally favourable for large-scale, multiple-purpose, basin-wide development. Through a hydraulic and electrical integration, the ultimate programme provides for the maximum practicable control and use of the considerable run-off, with upstream reservoirs and power plants balanced with downstream run-of-river schemes. The improvements also are being scheduled in proper sequence to provide the greatest benefits attainable at each stage of progress. At the present time, five stages for the progressive development of the water resources have been worked out, as follows :— The initial stage comprises the large schemes at



Proposed and Existing Developments in the Columbia River Basin

Bonneville and Grand Coulee, and is practically complete. The second stage involves those schemes that were under construction, or had been authorised by the Congress, in 1948; most of this work is now proceeding. The third stage consists of those schemes covered by an agreement between the U.S. Army Corps of Engineers and the Department of the Interior in April, 1949, which, at that time, were deemed most feasible to meet both the current and expected power demands until about 1965 and to meet the immediate flood control, navigation, irrigation and other water needs of the region. Under the fourth stage, the programme would be enlarged to include many additional projects that appear to be economically feasible and required to satisfy the growing needs of the region for water and power development. The fifth stage embraces a large number of other potential projects, which may be needed in future decades, and which generally require further investigation. It is believed that the possibilities for economical use of the water resources of the area are so extensive that several hundred projects will be required for their eventual full development. The major objects of the third stage scheme and the main control plan are outlined below; the accompanying illustration indicates the positions of the main impounding structures.

Flood Control.—Because of the lag in the construction of upstream projects, no large storage capacity is now available for effective flood control on the Columbia River, although four years have elapsed since the disastrous flood of 1948. Hungry Horse and Albeni Falls dams are the only storage projects at present under construction in the upper Columbia Basin. When completed, they will provide 4,000,000 acre-feet of usable storage. The programme, therefore, provides for about 27,000,000 acre-feet of storage on the Columbia and its tributaries above the Lower River flood plain. Multiple-purpose dams are proposed on the Kootenai, Clark Fork, Payette and Snake Rivers. Their storage would be regulated to provide for the maximum control of local floods immediately below the dams, as well as important flood control benefits downstream. Additional storage is also proposed on the main stem for the further control of floods on the Lower Columbia. A modification of the outlet valves at the Grand Coulee dam alone would provide a usable flood control storage of 5,000,000 acre-feet. By the combined operation of these reservoirs, the maximum flood on record (in 1894) would be reduced from a peak discharge of 1,240,000 cusecs at the Dalles dam to 800,000 cusecs. Below the Dalles dam, embankments would be built to give full protection against this latter flow. On the Yakima, Payette, Weiser and Crooked Rivers, storage would be provided for irrigation from which incidental flood control benefits, both locally and downstream, would be obtained. In the Willamette Basin, sixteen storage reservoirs having a useful capacity of over 2,000,000 acre-feet would control floods, improve navigation, and provide for irrigation. Five of these projects would generate power.

Navigation.—The programme is planned to allow economical water transport from tide-water on the Lower Willamette and Columbia Rivers well into the interior of the basin. Slack-water navigation for barges would be extended 135 miles up the Columbia from the Dalles dam to the mouth of the Snake River, then 141 miles up the Snake River to Lewiston, Idaho, and 30 miles farther by open channel to Lime Point, Idaho. A ship lock has been installed at the Bonneville dam to provide deep-water navigation to the Dalles dam. At the Dalles, John Day and McNary dams, and at the four lower Snake River dams upstream, locks will be installed to provide a 9ft draught to Lewiston, Idaho. From Lewiston to Lime Point, Idaho, low water restricts the draught to 6ft. The present and prospective river commerce is largely in bulk commodities, such as petroleum products, grain, ore, lime-stone, and heavy industrial products, including canned goods, paper and refined minerals. After the proposed waterway is completed it is estimated that more than 5,000,000 tons annually will be transported. Practically all the upstream and downstream movement would be to or from tide-water. The proposed dam at Priest Rapids includes provision for a lock, should navigation up the Columbia River above the Snake become justifiable to Wenatchee, Washington, a point 320 miles above tidewater at the Bonneville dam.

Irrigation.—Some 3,700,000 acres are irrigated in the Columbia River basin at present. Schemes under construction, including the Columbia basin project to be supplied from the Grand Coulee reservoir, will add 1,127,000 irrigated acres and deliver supplemental water to 665,000 acres which are now inadequately watered. In addition, authorised schemes, on which construction has not yet been started, would irrigate another 95,000 acres. Other, as yet unauthorised, projects in the third stage programme would irrigate about 217,000 more acres of new land and furnish supplemental water for 90,000 acres. The long-term programme proposes a continued investigation of other prospective irrigation developments, and the authorisation and construction of specific projects which are economically justified. Nearly 200 of the 400 potential schemes which have been identified to date under the comprehensive plan involve irrigation. Preliminary plans have been prepared for approximately one-half of these 200 potential irrigation projects. If all were completed, it is believed that agricultural production could be increased on 2·8 million more acres in the region. Of this total, 2·4 million acres are now not irrigated. Altogether, approximately 6,000,000 acres of new land could be irrigated in the region, and about 1·2 million other acres lacking sufficient water could be adequately supplied.

Power.—The Pacific North-West region has to-day an installed generating capacity of about 4900MW, including the facilities of the Federal Government, of private power companies and of municipal and other public systems. About 4500MW is hydro-electric capacity, the remainder being thermal power. Nearly 2500MW of the hydro-electric power capacity is concentrated in the Federal schemes at the Grand Coulee and Bonneville dams. Through the major transmission grid of the Bonneville Power Administration the various Federal and non-Federal power facilities are interconnected and operated as a pool, thus providing maximum availability of power throughout the region. Under the third-stage programme the installed capacity of the Federal system will amount to about 11,000MW, with a prime power capacity of 8000MW. This will include the 2500MW in operation, 3800MW in ten projects now under construction, as well as over 5000MW in projects either authorised or recommended. In addition, a number of smaller non-Federal power facilities are under construction and planned.

Some time ago a complete programme was prepared by the committee which could have provided 1000MW of additional capacity by the end of 1952 had it been started in the winter of 1950–51. Under this programme, urgent power requirements for defence industries would have been met partly by the large Federal projects and partly by smaller non-Federal works. Part of this immediate programme is now under way, but some of the works are awaiting private and Federal action. The report stresses that construction on the ten Federal schemes now in progress—McNary, Hungry Horse, Albeni Falls, Chief Joseph, Detroit, Big Cliff, Lookout Point, Dexter, Palisades and the Dalles dams—should continue as rapidly as possible. Construction of the private schemes currently scheduled for defence purposes should also continue as rapidly as possible, it is stated. Non-Federal schemes are needed to help meet the extraordinary power demands of the next few years, because their construction periods are generally shorter than for the larger Federal works. Because the output from all of the power plants under construction will be absorbed as rapidly as it becomes available, it is suggested that additional multiple-purpose power projects should be started immediately and followed in succeeding years by others in order to keep up with the requirements for the long-term economic growth of the area, and for national security. The major transmission grid of the Bonneville Power Administration is being expanded in step with construction of new generating facilities.

Water Supplies, Pollution and Wild Life.—The regulation of stream flow under the plan will provide larger and better water supplies for municipal, domestic and industrial uses. It will reduce stream pollution at low-water periods, especially on the smaller streams. Pollution abatement studies have been outlined for all the principal streams in the region, and measures for protecting the high quality of the water supplies in the region are continually being investigated and put into effect. Certain watershed protection measures are now in operation, such as fire control, limitations on logging methods and seasons, and tighter specifications for road location and construction and sanitary installations, but it is felt that much remains to be done.

To help build up the fish resources of the Pacific North-West an extensive programme of fish-life research, experiment and demonstration has been outlined. In addition, several projects, including the Lower Columbia fisheries programme, have already been started. This latter programme is intended to build up the present runs of salmon and other migratory fish in the lower and middle river and tributaries, and to establish new runs. Commenced in 1948, it was originally scheduled for completion in ten years, in view of the contemplated construction of five large dams on the Middle Columbia and Lower Snake Rivers. Although dam construction is behind the original schedule, the fishery programme is still farther behind, and the need for it has become increasingly critical. The transplanting of anadromous fish from one Pacific North-West stream to another has been successfully demonstrated. By this means fish runs that might otherwise be destroyed may actually be enlarged. Obstructions to fish passage, such as splash dams or natural barriers, are being removed. Hatcheries are being built and fish runs have been established where previously there were none.

Improvements at Tilbury Docks

THE Port of London Authority has authorised the carrying out of certain improvement works on the north side of the main dock at Tilbury Docks, to give additional accommodation for larger vessels of the Peninsular and Oriental Steam Navigation Company and the Orient Steam Navigation Company, Ltd. The total scheme is proposed in two stages under separate contracts and is estimated to cost in the region of £1,500,000.

The first contract provides for the demolition and removal of wartime "Pluto" installations and for the demolition of No. 1 shed and part of No. 2 shed (which are situated on the western side of the west branch dock, adjacent to the main dock), and the existing quay wall at No. 1 shed, so as to widen the main dock to 900ft and facilitate access for larger vessels to berths on the east side of the west branch dock. The construction is then envisaged of a monolith quay wall 843ft long along the main dock, having a depth of water alongside of 42ft 6in below T.H.W., and a return section of wall 240ft long which will form the southern end of the quay of a future branch dock.

The quay will be built on monoliths 30ft square with four wells, reinforced concrete shoes and mass concrete walls. After sinking, the monoliths will be sealed at the bottom and the back wells filled with concrete. The monoliths will be from 50ft to 60ft deep and founded on gravel. The spaces between the monoliths will be sealed with reinforced concrete piles. The quay superstructure will be carried on reinforced concrete beams resting on the monoliths. A service subway will be provided in the mass concrete cope. The quay will have two railway tracks and an 18ft gauge crane track to carry 3-ton electric cranes. An earth embankment is to be formed at the west end of the new quay.

The Authority has accepted the tender of Holloway Bros. (London), Ltd., for the first stage works described above. In addition it will be necessary to carry out extensive dredging.

The second stage of the scheme provides for the construction of a "T"-shaped single-storey transit shed, the main portion being 550ft in length at the head and 120ft wide, cargo loading and railway passenger platforms, roads and railways. It is anticipated that the scheme will be completed by the end of 1955.

Pametrada: Progress Report for 1952

THE Pametrada progress report for 1952, shows that, under its director, Dr. T. W. F. Brown, Parsons and Marine Engineering Turbine Research and Development Association has continued and expanded the research programme of the previous year. During the year the association has greatly increased its fund of knowledge and it is noteworthy that several licences to build turbines to the association's designs have been granted. The members of the Council and of the committees of the council are named, together with a note of the subjects discussed at the meetings and the report lists the papers read before the technical institutions, together with the subjects dealt with at the monthly senior staff lectures. Some twelve patents have been applied for and a statement of the full patents granted shows the number to be thirty-nine.

Design and Steam Turbine Research

Due to the need for the preparation of more detailed drawings of designs for foreign licence holders and the additional work involved in the consideration of engine-room auxiliaries, an increase in the design staff was necessary and the report notes that seventy-five design inquiries were dealt with during the year, representing a 60 per cent increase over 1951. Many of the designs were fully detailed and included machinery to operate normally at 14,000 s.h.p. on a single shaft, but to have a large reserve of power available. Another design was for oil tanker machinery of 12,500 s.h.p., taking steam at 600 lb per square inch and 950 deg. Fah., while compound turbines developing 5000 s.h.p. on one shaft were also designed. It is of interest to note from the report that an early design, prepared by the association, is being repeated for the Royal Yacht "Britannia" and that other designs also are being repeated by their original builders. Among the installations completed special mention is made of the 1500 s.h.p. units on board two ships built for Manchester Liners, Ltd. Upon investigation the cause of damage to a turbine in a cross-channel steamer was found to be insufficient flexibility in the seating, and the fact that the heavy rub which occurred only caused a small bend in the rotor was evidence that the design of gland was less vulnerable to gland rub than the normal pattern.

Other developments mentioned are the new forms of turbine cylinder joint and a tooth-type flexible coupling which is intended to improve lubrication of teeth and to reduce sleeve weight. A small emergency turbine for use in single-screw vessels having single-cylinder turbines has been designed and consists of a two-row wheel overhung from the shaft of an auxiliary pinion arranged to mesh with a primary gear-wheel. Further reference is made to the torsional vibration investigation carried out in the previous year and it is stated that wear in the gearing has not increased and that the adoption of quill drives to the main pinions has reduced the vibration torque. On the question of vibration it is recalled that the association's first impulse turbine went into service five years ago and that there has been no example of blade vibration failure.

The Steam Turbine Research department has been mainly concerned with the trials of Y.100 prototype machinery for the Admiralty and destined for an anti-submarine frigate, and these have been carried out in three groups, using a different gearcase in each instance. Tests were run using a number of lubricating oils in conjunction with three and five-point support, and noise and vibration measurements were taken on all three Maag gearcases. Several investigations have been undertaken on noise in completed ships, including surveys on three warships, both airborne and structure-borne vibration from main and auxiliary machinery being measured in H.M.S. "Diamond."

According to the report, an experimental unit has been designed for trials using steam at high temperature and pressure during which the performance of special high temperature materials will be assessed. Component research has continued and the report records the progress in a number of schemes, including turbine blade research rig, the development of an experimental condenser for the investigation of tube arrangement and size, circulating water velocity, fouling, &c.; testing of furnace fuel oil pumps; turbine gland strip tester; and a guarding valve for a sensitive vacuum gauge designed to withstand a 1000 lb per square inch water test and a 27·5in mercury vacuum test.

Gas Turbine Research

It is stated in the report that manufacture has begun of a single-stage, high temperature liquid-cooled turbine, for which ceramic nozzle blades are planned with sweat-cooled blades as an alternative. For testing the heat transmission in the rotor blades a rig provides for dummy blades to be rotated at 11,000 r.p.m., 850ft per second, and to be electrically heated.

Running tests of the 3500 s.h.p. marine gas turbine were continued after the completion of the modifications made following the completion of the 100-hour run made early in the year. Tests on the compressor showed that at 4500 r.p.m. the additional l.p. stage had increased the mass flow by 2 lb to 47 lb per second and the pressure ratio from 2·045 to 2·08. Notes are given regarding various runs of the turbine and of the measures adopted to rectify troubles, while tabular statements record the points obtained during runs made with the atmospheric temperature at 60 deg. and 80 deg. Fah. Further runs were made at different powers and then part-load trials were carried out, ranging from 30 per cent to 90 per cent power, during which it was found that for efficient operation the h.p. and l.p. turbine inlet temperatures should be equal, followed by a final run at 100 per cent power. The following is an extract from the results corrected to 80 deg. Fah. and 14·7 lb per square inch.

Load, per cent	30	40	50	60	70	80	90	100
S.h.p.	990	1320	1650	1980	2310	2640	2970	3300
Specific fuel consumption, lb per b.h.p. per hour	0·825	0·725	0·660	0·612	0·577	0·552	0·536	0·528
H.p. and l.p. turbine inlet temperature, deg. Fah.	920	975	1030	1080	1130	1180	1215	1250
H.p. turbine speed, r.p.m.	3650	3825	3970	4100	4225	4340	4445	4540

After preliminary trials on heavy fuel, using a solution of magnesium acetate as an additive, continuous running on Mothball fuel was started but after eighty-four hours the h.p. turbine fouled up and the h.p. compressor surged when the swallowing capacity of the turbine had been reduced by 20 per cent. A larger proportion of additive was tried but, according to the report, this resulted in an increased rate of fouling so magnesium acetate was abandoned as an additive and magnesium sulphate chosen for the next run, when the fouling was considerably less than before. During the year the set was running for 425 hours, the l.p. turbine being on power for 262 hours, and residual fuel was burnt for 113 hours.

Investigations into the question of vortex chamber erosion have shown that erosion can be considerably reduced by a suitable design. Other component research referred to in the report concerns welding trials of certain materials heated to 650 deg. Cent. for 1000 hours; work on refractory turbine blades which have been tested under realistic conditions of stress, temperature and thermal shock, temperatures up to 2200 deg. Fah. and stresses up to 2000 lb per square inch being used, and tests to determine the effectiveness of various corrosion inhibitors added to fuel oil, the emphasis being on corrosion prevention and the most promising at 1200 deg. Fah. being magnesium acetate.

Back-to-back gear tests have continued, S.G.B. gears have been tested to destruction and a set of Avgra hardened and ground gears were tested to 18,000 h.p. on one flank and 26,000 h.p. on the other, the noise and vibration being measured at 12,000 h.p. and 18,000 h.p. The programme of research on journal bearings having L/D ratios down to $\frac{1}{2}$ was completed and a considerable amount of running carried out to show the temperature in a bearing. The tests showed the importance of alignment and that the hottest point varied with running conditions and did not necessarily coincide with the load line.

Work has gone forward on both the Type "A" and Type "B" astern converters and on disc testers on which tests are in progress to determine the effect of oil viscosity and quality on pitting. Development of the gear pitch comparator has made progress and a small instrument was made for measuring progressive wear on tooth flanks, while a further study has been made of tooth contact conditions.

A section of the report deals with the developments and improvements in instrumentation, and this is followed by another section devoted to the development of new techniques and equipment for research such as a lighting-up unit for naval combustion equipment, and surface treatments for high temperatures in which tests on steel specimens showed that calorising is superior to aluminising.

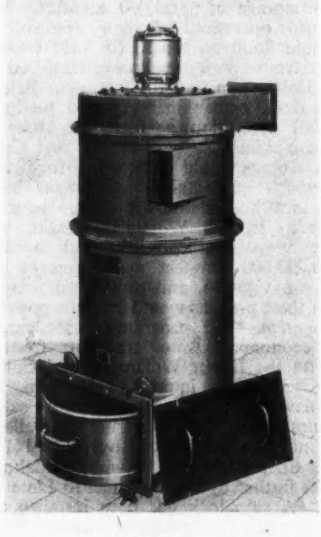
A Dust Arrester

We have received particulars of a dust arrester known as the "Uniclone," which is now being made in four sizes with capacities ranging from 450 to 1300 cubic feet per minute by the Sturtevant Engineering Company, Ltd., Southern House, Cannon Street, London, E.C.4.

In this machine, illustrated below, an exhausting fan has beneath it a cyclone and dustbin, all arranged in a compact cylindrical case.

In operation, dust-laden air is drawn into the machine by the paddle-blade centrifugal fan, fitted to the vertical shaft of an electric motor which is mounted on the top plate of the casing. The dust-laden air then passes into the cyclone from which the dust is deposited into the removable dustbin, enclosed by a dust-tight door at the base. The fan is fitted with a scroll, and arranged to discharge through a rectangular outlet which, in accordance with the Factories Act, can, if required, be connected to a further length of piping to discharge the air exhausted to outside atmosphere.

Suction piping can be designed to suit particular duties and machine set-ups.



"Uniclone" Dust Arrester

A Tubeless Tyre

AFTER many years of experiment, the Dunlop Rubber Company, has now introduced a tubeless pneumatic tyre for road vehicles, and we were able recently to see demonstrated some of its characteristic properties. It will be recalled that tubeless cycle tyres have been marketed in the past, but, as the company states, there had hitherto been serious obstacles to the application of such a tyre to motor vehicles. Amongst these obstacles was the fact that the rims for 17in and larger diameter tyres were not suitable and spoked wheels were inadmissible because of the danger of leak at the spoke heads.

It will be seen from the illustration that, instead of an inner tube, the tyre has a rubber lining of similar gauge bonded to the inside of the tyre, which fits a standard rim, and a valve of usual design is fixed through the valve hole of the rim. The pressure of the heads on the rim seats provides a seal proof against any escape of air providing the rim is clean and free from distortion. This rubber lining not only prevents leakage through the fabric, as would occur with an ordinary tyre, but it acts also as a puncture sealing layer, in that it clings to the nail or other foreign body which might penetrate it.

One such tyre was punctured by a number of closely spaced 2in nails during the demonstration and when placed in water the air sealing was seen to be complete.

It is possible that nails which penetrate the tread and casing will ultimately cause serious damage, even though no loss of air occurs. For this reason it is suggested that there should be an inspection after every 2000 or 3000 miles in order to remove any nails or other sharp objects which have been picked up. Objects like carpet tacks can easily be removed and no air leak will follow, but if a substantial hole has been made by a large nail it is likely that pressure loss will follow removal of the object. It will then be necessary to remove the tyre from the wheel and plug and patch the hole from inside with an ordinary vulcanised patch.

Section of Tyre with Nails Embedded

The rubber inner lining confers an additional benefit by protecting the casing if it should happen that the puncture sealant does not cope completely with an invading nail. In the past tyres have frequently been completely ruined by running them with slow leaks, and consequent under-inflation. This damage can be completely avoided with the tubeless tyre. Under-inflation is not recommended, but distances of up to 4 or 5 miles at a reasonable speed can be covered with pressures of half or a third of the correct figure without damage to the tyre.

The tyre damage resulting from collision with kerbstones and other large obstacles is not affected by the structural changes embodied in the tubeless tyre. The fabric can be broken just as in an orthodox construction. It is maintained, however, that the number of resultant bursts will be markedly reduced, and it has been demonstrated that the tubeless tyre can be run for a considerable number of miles without loss of air after the casing has been damaged to such an extent that an ordinary tyre would burst.

To demonstrate the effectiveness of the seal at the rim a heavy car was driven on a circular track of 15 yards diameter at 12 m.p.h., the side loading on the tyres resulting from accelerations of $0{\cdot}5g$ to $0{\cdot}6g$. After nine circuits the pressure of the tyres had risen by as much as 20 per cent on the outside wheels, due to the temperature changes of the tyre.

Production of the tyre at the moment is strictly limited and due to the high percentage of hand labour involved it is some 20 per cent more expensive than a comparable tyre and inner tube. The company hopes, however, to be able to reduce this cost considerably when a fully mechanised production technique has been evolved.

Linking of Projectors for Three-Dimensional Films

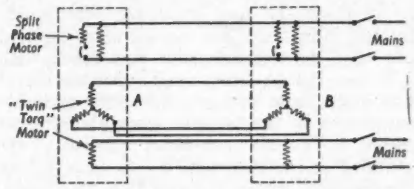
WHERE film exhibitors lack the space for a wide screen, involving as it does some sacrifice of forward seating capacity, the showing of three-dimensional films requires the linking of two projectors so that they both run in synchronism instead of alternately, as they do with non-stereoscopic film. The problem of keeping the two projectors accurately in step from start to finish when the projectors subtend an angle of approximately 6 deg. is more readily solved by electrical than by mechanical means. In the method developed by the General Electric Company, Ltd., use is made of a modified "Twin Torq" motor.

Most projectors are driven by a ¼ h.p. split-phase a.c. induction motor, running at 1440 r.p.m., and although this kind of motor is generally regarded as a constant-speed machine, it is nevertheless subject to small fluctuations of speed with varying loads. Consequently, if there is a difference between the load characteristics of two projectors, one motor will run at a speed slightly below that of the other. To correct this difference in speed for "3D" operation, one G.E.C. "Twin Torq" motor (a two-pole machine having a three-phase stator and a single-phase wound rotor fed from the mains through a pair of sliprings) is coupled to the driving motor of each projector, preferably by a direct chain drive from one motor shaft to the other. All four motors are then electrically connected as shown in the accompanying diagram.

Thus, if a split-phase motor loses speed due to an increased load on its projector the "Twin Torq" motor directly coupled to it also loses speed. This tendency to lag creates an angular displacement between the "Twin Torq" rotors on each projector, causing unbalanced voltages to be induced in both stator windings, with the result that current now flows from one stator to the other. This flow of current has the effect of producing equal and opposite torques on the "Twin Torq" rotors, causing both rotors to be pulled into step with each other.

The torque exerted by both "Twin Torq" motors is related to the mechanical difference between the two projectors. Where this difference in mechanical loading persists the "Twin Torq" rotors will not assume perfect alignment, but will be displaced from each other by a small angle, the value of which will depend upon the load and design of the motors.

Without practical experience over a prolonged period no accurate estimate can be given of the maximum out-of-balance forces likely to be met under all kinds of working conditions. One of the main causes of varying load can be attributed to the differing frictional losses in the bearings and other moving parts of the projector. Deposits of chemical emulsion from the film on the skids and guides of the projector, if not frequently removed, also increase friction and impose an added load on the motor. The G.E.C. has therefore developed the "Twin Torq" motor to exert a torque of 50 ounce-inches, with a full-load rotor displacement of 30 deg., and this is considered to be ample for all normal requirements.



Connection of Driving Motors of Two Projectors

The "Twin Torq" motors must take charge from the moment of starting up until the projectors finally come to rest. The correct sequence of switching is as follows: first, both "Twin Torqs" on; second, both split-phase motors on; third, both split-phase motors off; fourth, both "Twin Torqs" off, when projectors are at rest.

Existing projectors can be modified by the addition of "Twin Torq" motors and the company can also supply a composite motor incorporating the split-phase and "Twin Torq" motors in one frame for incorporation in new projection equipment.

Stettynskloof Dam, South Africa

ACROSS the Drakenstein Peaks from the projected Wemmershoek dam, a start is being made on the biggest water scheme ever undertaken by a town council in the Cape Western Province—the £1,250,000 Stettynskloof dam, to supply water to Worcester. This dam, which will supply two service reservoirs in Worcester through 22 miles of pipeline from one of the best catchment areas in South Africa, is being built with an eye to the vast possibilities for industrial expansion in the town. Worcester, situated in a rich farming area, is already the home of many secondary industries, most of them connected with fruit. The big Hex River power station was recently built there by the Electricity Supply Commission, and there are plenty of industrial sites and good transport facilities. Stettynskloof is in a forestry reserve in the Drakenstein range south of and parallel to Du Toit's Kloof. A 6-mile road has been cut through the mountains to the dam site at a cost of £32,000.

Work has started on the construction of living quarters for the resident engineer, the German technicians and hundreds of coloured labourers, who will build the concrete dam wall. The catchment area has an annual rainfall of 100in to 200in. The pipeline, which will be laid later, will pass over several farms, the owners of which will make no charge. Of the £1,250,000 cost of the entire scheme, £300,000 will be paid by the Government as a subsidy. The Government will have the right to raise the wall of the dam later to increase its capacity, and to use the water for agricultural irrigation in the area.

The Astin Case

(By Our American Correspondent)

MOST American scientists and engineers were deeply perturbed by the circumstances surrounding the sudden dismissal recently of Dr. Allen V. Astin as director of the National Bureau of Standards. One of the important questions which was raised by this unceremonious ousting was whether or not high technical positions in the Government are going to be subjected to political pressures whenever there is a change of Administrations. The dismissal raised a storm on Capitol Hill, in the American daily Press, in scientific journals and in the Bureau of Standards itself, and, as a result, Mr. Sinclair Weeks, the U.S. Secretary of Commerce, has now temporarily reinstated Dr. Astin. It may well be that President Eisenhower himself intervened, for the Secretary pointed out that the reinstatement was made with "White House approval." Moreover, it has been said that some 400 scientific employees of the Bureau were planning to resign. Though American scientists are gratified at the turn that events have taken, they want something better than the Secretary's partial reversal of his decision. A few weeks ago the Secretary held Dr. Astin responsible for a supposed lack of objectivity on the part of the Bureau in failing to approve a battery additive or revivifier known as "AD–X2." Now he "would emphatically point out that at no time has there been any intent, implied or otherwise, to cast reflection upon the integrity of the Bureau or the professional competence or integrity of Dr. Astin." Dr. Astin is reported to have said, "The professional integrity of the Bureau and my own integrity and competence have during recent weeks seemed to be in question." The scientists who worked for a reversal of the dismissal of Dr. Astin will agree. But they would like to know how Secretary Weeks can reconcile his condemnation of the Bureau's lack of objectivity with his new declaration that his differences with Dr. Astin "result from a conflict with respect to administrative viewpoint and procedure and have literally nothing to do with scientific evaluations or conclusions." The Secretary will also have to explain why he ordered the withdrawal from circulation of the Bureau's circular 504 on battery additives. In that circular it is said that "various preparations advertised to put new life into worn-out or so-called 'dead' lead-acid batteries, such as used in automobiles, have little or no value, it is shown from recent tests made by the National Bureau of Standards."

The Secretary is now proceeding with his plan to have the Bureau of Standards surveyed by what he calls the "best brains." A visiting committee appointed by law to inspect the Bureau from time to time is to submit a panel of names from which the Secretary will "expect to select a new director." If public confidence in the Bureau is to be restored, the new director ought to be an outstanding scientist whose attainments command national respect. It is not likely that any such scientist will now accept the position. The committee will probably have to fall back on the Bureau's own staff. Dr. Astin himself was once a staff research scientist, which indicates that there are good men in the Bureau who may qualify. Unless Secretary Weeks places himself unreservedly in the hands of a committee that commands the respect of the country's scientists the demoralisation of the Bureau of Standards is likely to spread to other Government agencies in which hundreds of scientists are employed. For this possible demoralisation, the politicians of Washington will be as much responsible as any Cabinet member. Dr. Wallace R. Brode, an associate director of the Bureau, shocked scientists and engineers when he testified recently before the Senate Appropriations Committee that twenty-four Senators had written to the Bureau of Standards and urged it to report favourably on the battery additive "AD–X2."!

The disapproval of "AD–X2" would ordinarily have passed without notice. But the manufacturer concerned brought it before the Senate Small Business Committee, which took more than a passing interest in it. The committee went so far as to ask the Massachusetts Institute of Technology to test "AD–X2." Its opinion was construed as at least a partial approval of the product, and Secretary Weeks made much of it. But Dr. J. A. Stratton, a vice-president of M.I.T., has publicly stated that "there are no recommendations included in the report, nor did our group arrive at any definite conclusions with respect to the commercial value of the product." In fact, the report expressly says that "a beneficial action from the standpoint of normal use" was not established, which is exactly what the Bureau said in the first place and what it is still saying. If any Government agency should be immune from outside pressure of any kind it is the Bureau of Standards. The Federal Government depends on it for basic and applied research and development in physics, mathematics, chemistry and engineering. Much like the N.P.L., it was founded primarily to set up national standards for weights and measures, to act as their custodian and to improve them. If the Bureau erred in disapproving an easily tested battery additive it may also have erred in determining what is a standard yard or a standard quart or a standard pound. The field which the Bureau covers has broadened over the years, and to-day a major aspect of its activity is the strengthening of national defence. Work is in progress in such fields as proximity fuses, atomic energy, guided missiles, ceramic coatings and communications equipment. The Bureau is the leading adviser on scientific matters not only to Government agencies, but to industry. When an engineering organisation or a manufacturing company needs help in drawing up specifications to govern the quality of a product or in framing a safety code, it is almost sure to ask for aid from the Bureau. If standard samples of chemicals, metals or other materials are wanted, the Bureau supplies them on request. Concerned as the N.B.S. is with testing and evaluating for the Government thousands of products and processes, it obviously cannot function properly if it is subject to political or other influence. It is not too much to maintain that if there is any important departure from the Bureau's established policy of rendering an impartial judgment on any matter with which it is confronted, scientific research is bound to suffer.

GRANITE SURFACE PLATES.—A recent test in the Metrology Division of the National Physical Laboratory has pointed out the advantages of granite, or diabase, as a material for surface plates. These advantages, it is stated, include freedom from corrosion, stability and extreme hardness, and, in addition, there is no burring if a heavy object is dropped accidentally on the plate. In the test at the N.P.L. a granite surface plate was used alongside a cast iron surface plate as a work support on a spot grinder, the work being slid backwards and forwards on the plate under the grinding wheel. The test was carried out for six months under these arduous conditions, the plates being used alternately. At the end of the test there was no measurable wear on the granite plate to within the accuracy of measurement, about ±0·00005in. The wear at the centre of the cast iron plate was of the order of 0·0004in.

American Engineering News

(By Our American Correspondent)

Annual Report of the American Bureau of Shipping

According to the latest annual report of the American Bureau of Shipping, there now exist in class with the Bureau 8500 vessels of 37,404,274 gross tons, of which about 20 per cent are temporarily inactive. To this figure there will be added 738 vessels under construction in American and foreign shipyards, making a total of 9238 vessels of 40,984,274 gross tons. While a substantial percentage of these vessels is foreign owned and registered, the large majority fly the American flag. These figures include seagoing tonnage, Great Lakes and river craft, both self-propelled and non-propelled. A total of 270 vessels was completed to American Bureau of Shipping Classification in American shipyards during 1952, involving altogether 514,568 gross tons. A total of 530 new vessels of 1,286,985 gross tons are now on order in United States shipyards to be built to American Bureau of Shipping Classification. The Bureau's business in foreign ports during 1952 has shown a continuing steady increase, requiring some additional expansion of its Foreign Surveying Staff. A total of fifty-three new vessels, aggregating 435,696 gross tons, were completed to Bureau Classification in foreign shipyards during 1952. Outstanding among these vessels is the "Andrea Doria," an Italian twin-screw passenger vessel of some 30,000 gross registered tons, which is propelled by turbines developing 45,000 s.h.p. The majority of these vessels were constructed in Japan, but included one in Trieste, five in Italy, five in Great Britain, three in Germany and three in Holland. A total of 160 new vessels of 2,059,426 gross tons are now on order in foreign ports to be built to American Bureau of Shipping Classification. A number of these will be finished in 1953, but others will not be completed until 1954 and 1955. Of these, twenty-seven are on order in United Kingdom shipyards, five in France, two in Belgium, thirty-four in Germany, six in Canada, seven in Mexico, six in Trieste, twenty-one in Italy, three in Spain, fifteen in Holland, three in Pakistan and thirty-one in Japan.

The report reviews a number of technical activities in which the staff of the Bureau has been active. Since the war there has been a steady increase in steam temperatures on turbine-driven vessels until now practically all new construction is being designed for temperatures between 850 deg. and 900 deg. Fah. This has made it necessary to use alloy steels for the high-temperature piping and the installations in America are now being made in accordance with the Bureau's "Interim Guide for the Installation of High-Temperature Piping on Ships." In the field of materials the action which was taken by the Bureau in 1947, in adopting revised specifications for hull steel plates, has continued to be justified not only by the service records of the vessels in which were used the improved materials obtained under the new specifications, but also by continued research projects. There has been growing recognition of these specifications in other fields of heavy plate structures where in recent years the need for improvement over previous standard steel specifications has likewise become apparent. At the half-yearly meeting of the Bureau held in July, 1952, it was reported that on April 4th of last year there was issued to all owners of "T2" tankers in class with the Bureau a directive calling for certain alterations to be made to provide additional safeguards against the repetition of such hull failures as resulted in the breaking in two of two of these tankers a year earlier. The work of complying with this directive has been proceeding at a rapid pace, with the result that at the present time the alterations have been completed on approximately two-thirds of the slightly more than 400 vessels of this kind in class with the Bureau. The Technical Committee also directed that there should be undertaken, in collaboration with the U.S. Coast Guard, the preparation of a "Manual on the Loading of 'T2' Tankers," to be made available to the operating personnel of tanker owners and to contain data to guide them in avoiding conditions of loading or ballasting

which might result in unusually severe longitudinal stresses. The work of assembling material and the printing of the booklet was completed last October. Finally, the Committee on Engineering recommended the Bureau to establish a special advisory panel on manganese bronze propellers to study material specifications, foundry practices and methods of repair or reconditioning with a view to making recommendations to improve the experience with propellers made of this material. There have been several meetings of the various sub-groups of this panel which have been investigating specific phases of the problem. The work is still continuing and while, as yet, no formal recommendations have been made, advantage has been taken of some of the discussions in initiating some changes in practice. The use of a new inert-gas-shielded arc-welding process has been tried in several instances in order to find out whether or not this will improve experience with welded repairs.

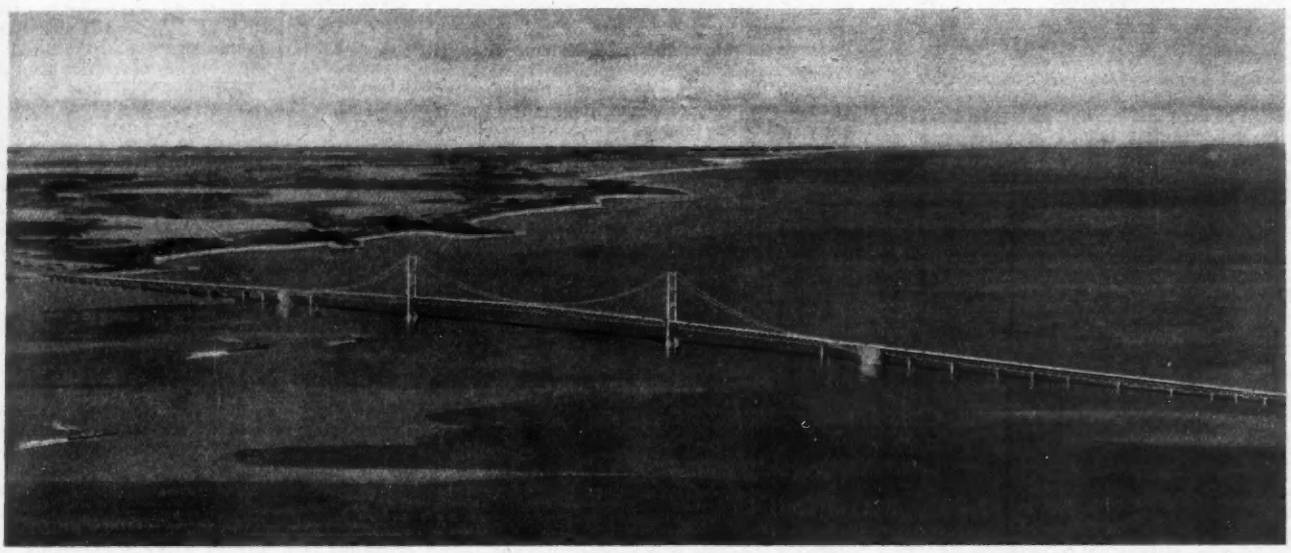
A Suspension Bridge Over the Straits of Mackinac

The Mackinac Bridge Authority has announced the award of contracts totalling 66,070,563 dollars for the construction of the proposed suspension bridge across the Straits of Mackinac connecting the upper and lower peninsulas of the State of Michigan. The structure was designed by Dr. D. B. Steinman, of New York City, acting as consulting engineer to the Authority, and an artist's rendering of the proposed bridge is reproduced herewith. The Merritt-Chapman and Scott Corporation, of New York City, was the successful bidder for the substructure work, which involves the construction of thirty-four piers varying in depth from 50ft to 200ft below mean water level. The American Bridge Division of the United States Steel Corporation was awarded the contract for the construction of the steel superstructure, which includes 9304ft of truss spans and a suspension bridge which is 8614ft in length from anchorage to anchorage. The main span of the suspension bridge will be 3800ft long and will thus be second only in length to the Golden Gate Bridge in San Francisco. Both contracts are contingent upon the successful completion of the necessary financial arrangements by the Authority.

Designed for a live load of 2000 lb per lineal foot, the bridge will carry two lanes of traffic in each direction, separated by a low, 2ft wide mall. The roadway will be 48ft wide between kerbs, and footwalks 3ft wide along both sides will bring the total width between railings to 54ft. The roadway will have a maximum grade of 2·5 per cent, which has been found to be ample to provide a minimum clear height above a mean lake level of 135ft for a width of 3000ft over the main channel. The minimum clear height at the centre of the main span will be 148ft. The bridge span will be suspended from two 24·25in diameter cables situated at a centre distance of 68ft and comprising thirty-seven individual strands. Each strand will be composed of 348 galvanised 0·196in diameter wires. The cable sag will be 350ft, equivalent to about one-eleventh of the centre span. The bridge towers will rise to a height of 552ft above lake level.

The consulting engineers believe that the structure will have the most aerodynamically stable cross section ever employed in a suspension bridge and quote the following points in support of that statement. The stiffening trusses will have a depth of 38ft, or 1/100 of the span. This ratio is the same as that adopted for the 3600ft span of the Severn River bridge and compares favourably with that for the 4200ft span of the Golden Gate bridge (1/168) and the 2150ft span of the Delaware Memorial bridge (1/107·5). In an effort to minimise the forces upon the structure due to wind pressure, the transverse floorbeams were designed as trusses rather than as solid web girders. Lateral trusses will be provided both in the planes of the top chords and the bottom chords of the stiffening trusses, leading to an increased torsional rigidity. Open spaces will be left between the roadway and the stiffening trusses, which, together with the open grating floor at the centre of the roadway and the open web floor beams, are expected to ensure aerodynamic stability.

In addition to the work already under contract the scheme will comprise 8267ft of approach roads and viaduct structures. The construction schedule, as established by the consulting engineers, calls for the bridge to be open to traffic by November 1, 1956. The Mackinac Straits bridge will replace existing ferries, which have been operated by the Michigan State Highway Department since 1923, and which have never provided adequate service nor overcome satisfactorily the physical separation of the upper and lower peninsulas of Michigan. The bridge will cut the actual crossing time from approximately fifty-three minutes to ten minutes, resulting in a saving of forty-three minutes, exclusive of waiting time for the ferries. This waiting time varies from one and a half hours in the autumn and winter to two and a half hours during the summer months. The records show that during certain peak periods, motorists have had to wait up to seventeen hours before being able to cross the Straits. Because of its strategic site, the Mackinac Straits bridge is expected to assume considerable importance as a major link in the interstate highway system established by the U.S. Congress in 1944 for the purpose of linking together the largest cities and principal geographic regions of the country and for the purpose of meeting the requirements of national defence for the rapid movement of military vehicles. The bridge will provide the only direct highway link from southern Michigan to the important locks at Sault Ste. Marie, which connect Lake Superior with Lake Huron.



Proposed Suspension Bridge Over the Straights of Mackinac

Industrial Participation in the Atomic Energy Programme

The U.S. Atomic Energy Commission has completed the negotiation of an agreement with the Pioneer Service and Engineering Corporation of Chicago, together with the Foster Wheeler Corporation of New York, governing the nuclear power reactor study which these two companies propose to conduct this year. This negotiation was begun some time ago when the Commission accepted the proposal of the companies to engage in the activities of the Industrial Participation Programme. These activities include a survey of the feasibility of the design, construction and operation by private industry of power-producing reactors. The Pioneer Service and Engineering Company is a firm of consulting engineers engaged in the field of electric power generation, and for the purposes of this reactor study, its staff has been augmented by a nuclear physicist and a nuclear engineer. The Foster Wheeler Corporation is well-known in America in the field of design and manufacture of steam generation, heat exchanger, petroleum refining and chemical process equipment. All costs of the research work will be borne by the two companies. The term of the study will be one year, after which time a complete report of the findings and recommendations of the two companies will be submitted to the Commission. The personnel engaged in this work have been granted the necessary security clearances to permit them to investigate pertinent phases of the A.E.C. programme. Access to the files and facilities of the Commission to an extent commensurate with the scope of the work will be granted. Specifically, the purpose and scope of the agreement are to determine the engineering feasibility of the companies' designing, constructing and operating a nuclear reactor; to examine the economic and technical aspects of building this reactor in the next few years; to determine the research and development work needed, if any, before such a reactor scheme can be undertaken, and to offer recommendations in a report to the Commission concerning such a reactor project and the part of industry in carrying it out. To accomplish these objectives the companies may employ, with the approval of the Commission, other organisations and persons as required. All inventions and discoveries made in the course of the work remain the property of the U.S. Government.

Metallurgical Topics

Some Aspects of High-Pressure Technique

THE April number of the *Transactions of the American Society of Mechanical Engineers* contains a series of papers presented at the seventh National Instrument Conference, organised by the Industrial Instruments Division of the A.S.M.E. in September, 1952. These papers covered a variety of high-pressure research and development with special application to chemical and geophysical problems. Professor B. F. Dodge, of Yale, reviewed the "high lights" of research in the field of high-pressure chemical engineering, carried out in that university since 1925, and especially during the last five years.[1] A practical and theoretical discussion of the

Fig. 1—Single and Double-Hub Rupture Discs

design of fixed and moving seals used for gases, oils and chemical liquids at super-pressures, i.e. pressures of 10,000 lb to 100,000 lb per square inch, was provided by B. A. Niemeier.[2] Rupture disc design, evaluation and bursting tests were dealt with by G. R. Prescott,[3] and pressure measurement by piston gauges and by electrical resistance wire gauges by D. P. Johnson and D. H. Newhall,[4] and by H. E. Darling and D. H. Newhall[5] respectively.

RUPTURE DISCS

The use of rupture discs as a quick-acting pressure relief device is well established in the chemical industry. High-pressure synthesis units must be adequately protected against abnormal pressure surges caused by malfunctioning of equipment or by chemical reactions which may threaten to occur with explosive violence. The paper by G. R. Prescott[3] gives the results of a recent investigation into the design and application of rupture discs at one of the Du Pont Company's works in West Virginia. The materials used there were a 90 : 10 copper-zinc

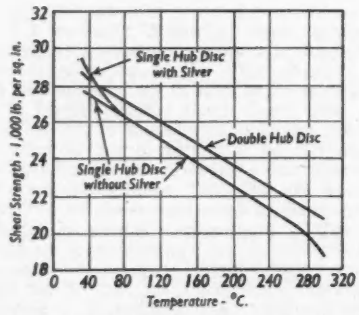


Fig. 2—90 : 10 Copper-Zinc Alloy. Effect of Temperature on Shear Strength

alloy (referred to in the paper as a "bronze") and a stainless steel containing chromium 25·5, nickel 3·7 and molybdenum 1·5 per cent. In practice single-hub discs only were used in both materials, but in the paper tests on some double-hub discs of the copper-zinc alloy (Fig. 1) are given, though no tests on the stainless steel are reported. The disc is placed in a holder, a shear block placed over the disc and the assembly tightened with a retaining nut. The rupture pressure $R=4st/d$, where s is the shear strength of the material, t the thickness of the disc and d the diameter of the shear block.

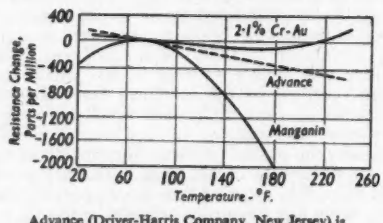
The 90 : 10 copper-zinc gilding metal discs were machined from half-hard plate stock, annealed at 420 deg. Cent. for thirty minutes and air cooled. The uniformity of any one batch of discs was checked by testing 10 per cent of the discs in a dead load machine. The effect of machining tolerances on rupture pressure is discussed. The ideal rupture disc material should have a small plastic range, but even when there is some plastic deformation due to intermittent pressure or to creep before failure occurs the reduced thickness is offset by increased hardness due to strain hardening.

The effect of temperature on the rupture pressure of the gilding metal discs was determined over the temperature range, 30 deg. to 300 deg. Cent. In actual service a silver disc is often used over the single-hub disc to resist corrosion, and the calculated rupture pressure of the composite disc is based on the sum of the bursting strength of the two components. Bursting tests were made on the single-hub disc, the single-hub disc with 0·003 in silver, and the double-hub disc 0·003in thicker than the single-hub disc. Variation of strength with temperature is shown in Fig. 2. The shear strength of the double-hub disc is (owing to its greater thickness) always higher than that of the single-hub disc, but the rate of decrease with temperature is somewhat less, an effect which must be attributed to the design. At room temperature the strength of the composite single-hub disc is enhanced by an amount which agrees closely with the shear strength of the silver, but its strength falls off rapidly between 30 deg. and 60 deg. Cent. Above 60 deg. Cent the curves obtained with and without silver coincide; the silver contributes nothing to the strength above this temperature.

For high-temperature applications the ideal rupture disc material should retain its mechanical properties at the operating temperature and have a high creep strength. When such a material as gilding metal is used it is necessary for rupture discs to be designed on the basis of both operating pressure and temperature, and for this purpose an experimental determination of variation of strength with temperature is essential.

A HIGH-PRESSURE WIRE GAUGE

As a result of the pioneer work of Dr. Bridgman the use of a manganin wire resistance coil has become very general in laboratory investigations of high-pressure phenomena. Although temperature affects the resistance of manganin only slightly over a narrow range, time often has to be allowed for the temperature of the wire to come into equilibrium before the pressure change can be distinguished from a temperature change. This is a disadvantage of manganin when high-pressure sensing devices



Advance (Driver-Harris Company, New Jersey) is approximately 55 : 45 Copper-Nickel

Fig. 3—Effect of Temperature on Electrical Resistance of 2·1 Per Cent Chromium-Gold Alloy, Advance and Manganin.

are required for the control of continuous industrial processes. Much work has been done on the development of gold, silver and copper alloys with a better temperature-resistance relation than manganin. In the work of A. Schulze,[6] alloys of gold with 2 to 4 per cent of chromium showed most promise, and these were further studied at the U.S. National Bureau of Standards.[7] In this range almost any temperature coefficient, positive, negative or almost zero, can be obtained by suitable choice of composition and treatment. Wire of gold-chromium alloy containing 2·1 per cent of chromium is recommended by H. E. Darling and D. H. Newhall[5] as having properties which make it particularly suitable for a pressure-sensing element for industrial purposes. It responds rapidly to pressure changes, it has a high degree of discrimination between temperature and pressure effects, it has adequate resistance sensitivity to pressure and material with a

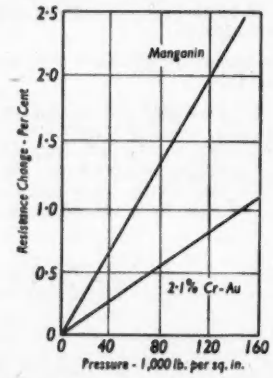


Fig. 4—Effect of Pressure on Electrical Resistance of 2·1 Per Cent Chromium-Gold Alloy and of Manganin

high degree of uniformity is available. Its properties are shown in Figs. 3 and 4, in comparison with those of manganin. Actual values over the temperature range 40 deg. to 200 deg. Fah. (4 deg. to 93 deg. Cent.) are :—

	Temperature sensitivity, per deg. Fah.	Pressure coefficient, per lb per sq in
2·1 per cent chromium in gold ...	+1 to −1 p.p.m.	... 0·67 to 0·72×10⁻⁷ ohm per ohm
Manganin	+5 to −40 p.p.m.	... 1·69 to 1·72×10⁻⁷

Although the pressure sensitivity is only 33 per cent of that of manganin, the smaller temperature sensitivity of gold-chromium results in good discrimination between temperature and pressure changes. Readings do not show the drift with time so characteristic of manganin, but quickly come to a steady value. It is generally stabilised by a single application of pressure as compared with several cycles usually required by manganin. Its long-time stability compares favourably with that of manganin. The authors express the opinion that 2·1 per cent chromium-gold wire should replace manganin as a standard for applications to industrial and control problems. As the hard-drawn wires have a larger temperature coefficient, the annealed or half-hard wires are recommended for pressure coils.

[1] *Trans. A.S.M.E.*, April, 1953, page 331.
[2] *Ibid.*, page 369
[3] *Ibid.*, page 355.
[4] *Ibid.*, page 301.
[5] *Ibid.*, page 311.
[6] *Chemiker Zeitung*, July, 1943, Vol. 19, page 228.
[7] U.S. Bureau of Standards, *Journal of Research*, 1934, Vol. 13, page 681.

The European Zinc Industry

AN interesting and valuable survey of the European zinc industry was presented by Mr. R. Lewis Stubbs, Director, Zinc Development Association, to the thirty-fifth annual general meeting of the American Zinc Institute on April 27, 1953. Reviewing the development of the industry, he recorded that the first European zinc was made at Bristol in 1740, but that production was not significant until horizontal retorts were invented in Silesia in 1798. The Belgians made improvements to the horizontal retort process in 1807, and it had not altered much since. Smelters based on nearby mines were founded in Russia (1816), England (1835), France (1855), Spain (1866), Holland (1893), and Italy (1897). The Belgian and some other mines

were nearly exhausted by the end of the century, but the Silesian ore body, on which the German industry was founded, is still an important source of zinc, although it is now behind the Iron Curtain.

At the outbreak of the first world war two-thirds of the world's production was in Europe, one-third of the metal being derived from imported ore. By 1909, the U.S. had become the largest single producer. Germany was the biggest producer in Europe, and, with Belgium, accounted for three-quarters of the European output. The war dislocated production in Europe, and it was not until the early '20s that it regained its previous level ; by 1921 Belgium had become the biggest European producer. About this time selective flotation was developed to treat complex sulphide ores, of which large quantities were available, and the concentrate produced was particularly suitable for electrolytic refining. This invention had serious repercussions in Europe, since it led to the growth of important refining industries in Canada, Mexico, Australia, Indo-China, Japan and later in Rhodesia. The whole period between the wars was one of great uncertainty for the European industry and its steady expansion was checked. Although, in 1938, it still accounted for about two-thirds of the zinc made outside the U.S., the growth of overseas smelters had weakened the position of those in Europe, which were dependent on imported ores for almost half their production. The second world war resulted in changes which even more seriously affected the European industry, owing largely to the loss of the Silesian industry to Russia. The U.S. has become an even larger net importer than Europe of both concentrates and metal, and Western Europe's relative importance as a zinc producer has declined since the war.

Turning to post-war developments and prospects of European production, Mr. Stubbs was able to give a more encouraging picture. Important developments in Belgium, France, Italy and elsewhere are described. Production is still mainly from horizontal retorts which accounted for nearly two-thirds of the 1952 total ; 22 per cent came from the more modern electrolytic refineries and 14 per cent from vertical retorts. Belgium, the largest producer outside the U.S., with a net export surplus of metal, is entirely dependent on imports of concentrates. Britain, the largest consumer outside the U.S., is dependent on imports of concentrates and metal.

The rate of consumption per head of population varies from country to country with Belgium highest at about 16 lb per head in 1950, U.S. 14 lb per head, Britain 11 lb, while in Greece and Portugal it is less than ½ lb per head. The pattern of consumption also varies as shown in the following table :—

Pattern of Virgin Zinc Consumption in 1950

Percentage consumed in	Western Europe without U.K.	U.K.	U.S.A
Galvanising	32	40	45
Rolled zinc	35	12	7
Die casting	6	14	30
Brass	11	21	15
Zinc oxide	5	12	3
Miscellaneous	11	1	—

The most striking feature is the relative importance of rolled zinc in Europe and of die casting in the U.S. and Britain. Rolled zinc is the traditional metal for roofing in France, Belgium, Spain, Denmark and in most of Germany. Some 87 per cent of all the roofs in Paris, for example, are zinc. France, Belgium and Spain use over half their zinc for rolling. Galvanising, unlike zinc rolling, is steadily increasing, although its growth in recent years has been somewhat hampered by the steel shortage. Galvanised sheet is less used in Europe for fabricating into hollow ware and for roofing than it is on the American Continent, but in Britain there has been widespread adoption of galvanising for rust-proofing steel window frames : over 95 per cent of all the steel windows made are protected in this way. Strip galvanising has not yet assumed the importance that it has in the U.S. and there are only four lines in Europe—two in Britain and two in France.

Die casting is the only important new use for zinc which has been developed in the last 100 years, and, thanks to the enterprise of the New Jersey Zinc Company and of the Imperial Smelting Corporation, zinc alloy die casting has become an important use of zinc in the U.S. and in Britain. During the war the annual consumption for this purpose in Britain reached 50,000 tons. Many of the smaller European die casters continue to be worried by contaminated products unsuitable for zinc alloy die castings, but this difficulty is being met by the recently introduced French certification scheme and by British Standards Institution specifications. Brass is still relatively much more important in Britain than in the U.S. On the Continent its production was curtailed by wartime shortages of copper. Zinc oxide was in good demand for paints during the immediate post-war period, but more recently its use has declined sharply.

In conclusion, Mr. Stubbs referred to efforts which are being made to increase the consumption of zinc by seeking new uses and solving common problems. In Britain, the Zinc Development Association* has done an immense amount to stimulate interest in zinc and so promote its use, and owing to its friendly relations with producers and consumers all over the world and its co-operation with other organisations doing similar work in other countries, it has naturally become the central body for advice and exchange of information on all aspects of the production and utilisation of zinc.

Mr. Stubbs' address was supplemented by statistics of zinc ore and metal production, and of consumption of refined zinc, in all countries of Western Europe, and by a list of all the European zinc-producing companies.

The Dilastrain Method of Fatigue Testing

WHEN small cylinders of steel and of extruded magnesium were subjected to a succession of increasing compressive stresses (S), it was found that an abrupt reduction of coefficient of linear expansion α occurred at the initiation of yielding.[1] The change for steel was about 5 per cent and for magnesium a little larger, and in each case the fall at the yield was followed by a sharp rise as the applied stress was increased. An example is shown in Fig. 1. The method was held to give

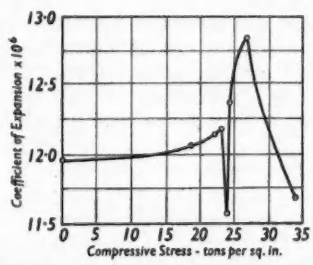


Fig. 1—Relation between Coefficient of Linear Thermal Expansion and True Compressive Stress for 0·29 per Cent Carbon Steel Nominally Hot-Rolled, but Showing Some Cold Work (Rosenholtz and Smith)

the value of the " true yield " for steel and also for non-ferrous metals in which yielding took place more gradually.

When applied to specimens of aluminium alloy which had been subjected to a constant number of reversals of stress below, near and above its known fatigue strength, the α–S curve showed an abrupt change after application of a stress a little below the actual value of the fatigue strength as measured at 5×10^8 cycles. This change was held to have occurred at the " true fatigue strength " of the alloy.

On the basis of such results as these, J. L. Rosenholtz and D. T. Smith,[2] of the Rensselaer Polytechnic Institute, Troy, N.Y., proposed the Dilastrain technique as a rapid method of fatigue testing. This method of determining the true fatigue strength consists of prestressing eight test bars and subsequently measuring their thermal dilatation in a special Dilastrain analyser. For steels, 50,000 to 100,000 cycles of stress are applied to each specimen, the stresses being chosen in steps of 5000 lb per square inch to span the region from a little below to well above the expected fatigue limit. An example of the type of curve produced is shown in Fig. 2, in which the eight specimens of a 0·2 per cent carbon steel had been subjected to 100,000 cycles of reversed bending at stresses between 38,000 lb and 45,000 lb per square inch. When the fatigue limit has been obtained approximately, the test may be repeated if desired with stress intervals of 500 lb or 200 lb per square inch to get a more accurate result. The fatigue limit in torsion can be determined by the same method. Examples are quoted of a 0·4 per cent carbon steel which gave a fatigue limit in reversed bending of 39,000 lb per square inch compared with 40,000 lb determined by the conventional method ; a naval brass, the fatigue limit of which was found by the dilastrain method to be 19,800 lb to 20,000 lb per square inch, compared with an observed value of 21,000 lb per square inch at 10^8 cycles and a complex alloy (Allegheny Ludlum[T]S–590), which gave a Dilastrain fatigue

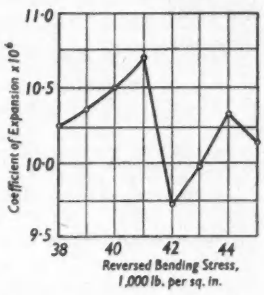


Fig. 2—Dilastrain Curve for a 0·2 per Cent Carbon Cold-Rolled Steel Subjected to 100,000 *Cycles of Reversed Bending at the Stresses Indicated. Fatigue Limit,* 42,000 *lb per Square Inch (Rosenholtz and Smith)*

limit of 60,500 lb to 61,000 lb per square inch as against 62,000 lb per square inch observed from the S–N curve at 2×10^8 cycles where it still had a downward trend. The advantages claimed for the Dilastrain method are speed and increased accuracy due to the absence of scatter.

As might be expected, so novel a method of fatigue testing has not been accepted without comment. In *Metal Progress*, November, 1952, N. Grossman raised a number of questions with regard to the interpretation of results, and a reply to his queries was published by Rosenholtz and Smith in March, 1953. He questioned the relation between fatigue limits and yield which seemed to be implicit in the method, and raised objections to the new definitions of " true yield " and " true endurance limit." Rosenholtz and Smith defended the term " true yield point " as the stress at which materials show a definite and abrupt change in physical properties when subjected to static loads, and not an arbitrary point based on some percentage permanent deformation. The " true endurance limit," they said, had a parallel connotation when the material was subjected to repeated load cycles. It is clear that the method is only suitable for finding the fatigue limit. This is the only point in common to the α–S and S–N curves. The method cannot, at present, be extended to endurance at other stress levels. Surface conditions are claimed to be less important than in conventional testing, for the reason that not more than 100,000 stress cycles are used ordinarily in the Dilastrain method and this is an unimportant percentage of the total number of cycles at, or near, the fatigue limit in the S–N curve. The same argument would presumably apply to the presence of inclusions and other stress raisers in the material. Nevertheless, the originators of the method claim that it has possibilities for the evaluation of surface condition. The linking up of fatigue limits with phenomena connected with the yield point appeared to Grossman to have questionable validity, and this may raise doubt and difficulty in dealing with metals and alloys in which the fatigue limit is above the yield point. There are, however, many questions of a fundamental character to which the answers are not yet available. They must await the results of further research on the method.

* Lincoln House, Turl Street, Oxford.

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PRESSURE-CHARGED DIESEL ENGINES

The post-war demand for merchant ships of increased deadweight capacity and faster speeds, together with the economy in maintenance costs now offered by diesel engines of up to 12,000 b.h.p., lend added interest to the suggestions of the Engineer-in-Chief of the Navy, recently discussed in this journal. In brief, Sir Denys Maxwell suggested that it is technically feasible to make a substantial reduction in the amount of material used in the construction of steam turbine machinery for merchant ships, and hence in its weight and cost, without increase in maintenance or loss of efficiency. The Merchant Navy will no doubt give his arguments and conclusions as careful study as it is already giving to the possibilities of the gas turbine. Both studies will clearly have a direct bearing on the more immediate problem facing shipowners at the present time—whether or not to continue the swing over to steam which has been apparent since the war for vessels requiring powers of some 8000 b.h.p. and above. In the United States the vast majority of cargo vessels and tankers in this category use steam propulsion. But that preference is beyond doubt largely due to lack of experience in building and operating large slow-speed oil engines. By contrast there is very little evidence of a preference for turbine machinery in the Scandinavian countries. Norway, for example, has at the present time no less than seven 32,000-ton ships on order which are to be propelled by single diesel engines of 11,000 b.h.p., giving a speed of over 15 knots.

In recent months this problem of deciding between the merits of differing power plants has been further complicated by the application of the exhaust-gas-driven turbo blower to marine two-cycle diesel engines. For during recent years there have been great advances in this field and power increases up to 50 per cent above the uncharged ratings having been satisfactorily achieved. Steam machinery therefore now faces competition from higher-powered diesel engines available at lower capital cost. To Burmeister and Wain, Ltd., of Copenhagen, has fallen the honour of having the first exhaust gas turbo-charged two-stroke engine at sea in the " Dorthe Maersk," a tanker completed six months ago ; and already as many as thirty supercharged two-stroke engines are under construction by this firm and its licensees, including four now being built by Harland and Wolff, Ltd., for Alfred Holt and Co.'s new Blue Funnel Line vessels. It is of interest to compare these engines with the non-pressure charged engines installed in that company's ships of the " Bellerophon " class, which are of approximately the same tonnage as their newer ships—7700 gross tons. The " Bellerophon " class have seven cylinder engines giving 7000 b.h.p., as compared with six-cylinder engines of the same bore fitted with turbo blowers and giving 8000 b.h.p. in the newer vessels. This advance in design has resulted in a reduction in machinery weight of about 90 tons to 100 tons in 500 tons, with a consequent substantial saving in capital cost, and also in a reduction by 9ft in the engine-room length. Apart from the increased speed given by the extra power, fuel consumption, power for power, is expected to show a reduction of 5 per cent, amounting to an annual saving of about £2500 for each ship. Other manufacturers here and abroad are developing two-stroke supercharged engines.

Broadly speaking, the gross saving on capital cost on a 9000 s.h.p. two-stroke engine, employing moderate turbo pressure charging to raise the power output to 12,000 s.h.p., is estimated to be of the order of £50,000. Moreover, experience to date of turbo pressure charging, which includes many years with the four-stroke application, suggests that any adverse effect on engine reliability is improbable, for in many installations the improved thermal conditions due to the excess air delivered by the turbo blower have in fact reduced the frequency of overhauls. The fewer or smaller cylinders of the turbo pressure-charged engine also make it easier to maintain than the larger uncharged engine of equal power. It seems possible, indeed, that the fundamental advantages of reduced initial capital cost and reduced specific fuel consumption at all loads will eventually result in the universal application of turbo pressure charging to all but the smaller two-stroke diesel engines. Danish and Dutch marine engine builders have taken the lead in pressure-charged two-stroke engines in that they have constructed engines of this kind for ships built or building. But British firms are also making good progress in the development of pressure charging arrangements and the range of turbo blowers already manufactured in this country is suitable for engines of the largest sizes. It is in fact clear that unless comparable advances are being made with steam machinery under the stimulus of naval criticism, diesel machinery, not forgetting geared diesels, may prove able to encroach into a range of powers formerly regarded as the field of the steam turbine. Thus marine steam machinery and the marine diesel are renewing the beneficial competition of pre-war days. In the background is a third competitor, the gas turbine, whose competitive power lies yet unproved.

GUIDED BOMBS FOR NEW AIRCRAFT

At the conclusion of the exercise " Jungle King " by R.A.F. Bomber Command, Air Chief Marshal Sir Hugh Lloyd, its Commander-in-Chief, reported that on certain of the new jet bombers in production guided bombs would be used, for the first time, by the R.A.F. In this way it is hoped to increase materially the accuracy with which bombs, from all heights and in all weathers, can be placed on a specific target. It may be taken for granted that some of them at least will be self-propelled, since the practice of using freely falling bombs, even with the best assistance that any visual bomb-sight can give, is almost if not quite out-of-date. A freely falling bomb suffers from the handicap that its average speed to the target is inconveniently low, and accuracy would be enhanced by the addition of a certain degree of self-propulsion instead of relying solely for its speed on the force of gravity. Accuracy could, in principle, also be gained by guiding the path of the bomb during its fall, though the specific merits of self-propulsion and of the use of the guidance principle are quite distinct developments. Either one, or both together, can be used in the needful drive towards high precision in bombing. That part of the U.S.A.F. which supports the nuclear weapons programme of the Atomic Energy Commission is reported as having obtained in some recent tests at the Nevada Proving Ground bombing errors of less than 100 yards during certain " high-altitude releases." For this type of weapon that was no doubt amply good enough ; details are not given, however, of the methods used.

The passage of the years has not, as it happens, made this important objective the easier to attain—rather the contrary. The recent substantial increase in bomber air speed had added greatly to the horizontal distance from the target at which release must needs take place. For a freely falling bomb the time of fall from 10,000ft will be about half a minute, and twice that from 40,000ft. Thus, an air speed at the moment of release of 600 m.p.h. means a horizontal travel before the ground is reached of about 5 miles in the former case and about 10 miles

in the latter. Hence, from a bomber at 40,000ft altitude the target must needs be recognised when as far away as 20 miles, if one allows no more than about forty seconds to confirm the accuracy of identification. This is twice as far as from the Tower of London to Kingston-on-Thames, so it will be realised how easily mistakes in identity might be made. This is certainly an argument in favour of the missile being guided whilst in flight since any aiming errors made at the point of release can in some measure at least be subsequently corrected. It tells also in favour of the bomb being self-propelled, for the time of fall is thereby lessened, and the appropriate release point will not be so inconveniently remote from the target. The best kind of self-propulsion to employ is a very arguable matter. Some methods can preserve a more uniform speed than others, though this is less important if really effective guidance can be attained. It is the problem of making guidance effective that seems likely to present the chief difficulty. If such control is to be the task of the bomber crew the geometry of the problem presents a good deal of complexity. If, on the other hand, the bomb is to be of the self-guiding sort, there is the still greater difficulty of its entire lack of intelligence in target identification! These problems are tough enough. But if there have also to be added those involved in the location of targets by radar methods, however ingenious, they do, indeed, make an aggregate demand, such as may well justify Sir Hugh Lloyd's opinion that the future recruitment for the R.A.F. must include, for air and ground duties alike, an adequate proportion of the very best young men that the nation can produce.

It will naturally be asked whether any bomb which is self-propelled and self-guided during flight might not just as well carry its own wings and so dispense entirely with any carrier aircraft or any aid which its bomber crew could give. Much experimental work has been done in this direction in the United States and some no doubt at the testing range in Australia, too; we read that a Martin pilotless jet bomber is now in production in U.S.A. and already in use at the Air Force Missile Test Centre in Florida for the training of the first A.F. Squadrons to be entrusted with the task of operating its ground launching procedure. A much smaller programme of guided missile development is in progress in Britain, the achievements of which are little known, and it would be of advantage if they became the subject of informed discussion among the younger serving officers whose enthusiasm must be kindled. It is also arguable that the veil of secrecy which conceals British technical progress in methods of rocket propulsion ought to be raised. If it were to some extent lifted its seems to us that progress could be accelerated by allowing some of its general problems, as distinct from those of the particular military application, to be discussed by a civilian body such as the Institution of Mechanical Engineers.

VENTURE IN EDUCATION.—We have received from the Shell Petroleum Company, Ltd., a booklet which describes how the relationship of industry to education has developed in the Royal Dutch/Shell group of oil companies. Particular reference is made to the close association with the universities and to the various grants made for the furtherance of the study of geology, geophysics, chemistry and chemical engineering, and for technical research.

Obituary

LORD ABERCONWAY

SHIPBUILDERS, engineers and those associated with the coal, iron and steel industries will have learned with regret of the death of Lord Aberconway, which occurred on Saturday, May 23rd. The Right Honourable Sir Henry Duncan McLaren, the second Baron Aberconway of Bodnant in the County of Denbigh, was born on April 16, 1879, and educated at Eton and Balliol College, Oxford, before being called to the Bar in 1905.

He followed the family interest in politics and sat as Liberal member for West Staffordshire from 1906 to 1910 and then succeeded his father as Liberal member for the Bosworth Division of Leicestershire, a seat which he held until 1922. Henry Duncan McLaren closely followed in the footsteps of his father, the first Lord Aberconway, who served as a Member of Parliament for a number of years and who, after a successful career at the Bar, became keenly interested in industrial development. His activities were widely spread over the fields of shipbuilding, engineering and associated industries and his son, who succeeded as second Baron in 1934, also became closely linked with his father's industrial interests and eventually became chairman of John Brown and Co., Ltd., Tredegar Iron and Coal Company, Ltd., Yorkshire Amalgamated Collieries, Ltd., Sheepbridge Coal and Iron Company, Ltd., and, before nationalisation, of Thomas Firth and John Brown, Ltd. Among his other interests he was a director of the National Provincial Bank, Ltd., and the London Assurance.

Lord Aberconway had many activities outside his work in industry, the most outstanding being his keen interest in gardening, and part of the gardens at Bodnant, adequately endowed, he gave to the National Trust. Gardening being one of his main recreations, it gave him particular pleasure to be the President of the Royal Horticultural Society, a position which he had held since 1931.

Literature

Physical Similarity and Dimensional Analysis. W. J. DUNCAN, F.R.S. London: Edward Arnold and Co., Ltd., 41, Maddox Street, W.1. Price 30s.

IT may appear strange at this date to say that a book on dimensional analysis is a pioneer work, but that is precisely the correct description of Professor Duncan's *Elementary Treatise*. As the title indicates, the framework of dimensional analysis is here securely grounded on the foundation of the theory of physical similarity instead of being apparently an end in itself. The exposition of the theory of physical similarity is set out with remarkable clarity and this should enable the reader to understand and use dimensional analysis with real benefit and avoidance of the occasional howlers which are made as a result of a blind use of the method with insufficient understanding. The substitution of the term "measure formula" for "physical dimensions" is a minor improvement which should lead to greater clarity of thought, and special importance of the Froude number in problems of dynamic similarity is brought out into the pre-eminent position which it should—and does not always—occupy. It is, perhaps, a pity that in doing this the name Froude number should have been extended to cover not only the familiar group V^2/lg, but also Weber's number $V^2\lambda\rho/\sigma$, Reynold's number Vl/ν, and the square of the Mach number $V^2\rho/K$, although it is not disputed that all four groups are fundamentally criteria of the same conditions for similarity.

After introducing the idea of dimensional groups the author brings out clearly the meaning of geometric and dynamic similarity and then applies these ideas to dimensional analysis. This is then illustrated with reference to fluid mechanics before dealing with Buckingham's Pi Theorem. Further illustrations are then given from thermodynamics and electromagnetism, followed by a first-rate chapter on a critical review of dimensional analysis. The book finishes with two rather miscellaneous chapters entitled "The Use of Non-Dimensional Coefficients in Design" and "Detailed Arguments Based on Similarity," of which the former deals with examples from fluid mechanics—forward and reversed propellers and pumps, and aircraft—whilst the latter deals with deflections in cantilevers and membranes and with a problem in electrostatics. A number of hares are started which are not followed, such as the discussion of virtual mass of an immersed body (page 65), and some of the matter is of a level of difficulty and specialisation which appears out of place in an elementary treatise; under this heading might be placed the note on similarity in non-Euclidean geometry and some of the aerodynamic material. Nevertheless, the reader can omit or skim over these sections without losing the main thread. Although the order of topics may at times seem arbitrary or open to improvement and there are these minor criticisms of content, they are trifling in what has already been noted to be a pioneer work which is readable, of sustained interest and fills a real need. This is a work of quite exceptional merit.

The value of the book would be enhanced by a bibliographic appendix collecting together the references scattered through the text in readily traceable form. Professor Duncan would increase our debt to him if this were not only done, but extended to be a brief guide to the literature succinctly reviewed in the author's lucid style.

SHORT NOTICES

Problems in Hydraulics. By R. S. Paradise. Glasgow: Blackie and Son, Ltd., 17, Stanhope Street, C.4. Price 7s. 6d.—Students studying for a final degree or equivalent examination will find in this volume a selection of fully or partly worked problems in hydraulics. Each chapter is set out with a brief outline of the principles and formulæ of the topic with which it is concerned, followed by a number of examples of the application of these principles and formulæ to specific problems. There are 449 problems in the volume, of which 126 are fully solved. The chapter headings cover generally the normal syllabus of the study of hydraulics at this stage.

BOOKS RECEIVED

Modulators and Frequency-Changers. By D. G. Tucker. London: MacDonald and Co. (Publishers), Ltd., 16, Maddox Street, W.1. Price 28s.

Radio Engineering, Volume II. By E. K. Sandeman. Second edition. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 55s.

Iron and Steel Directory. Seventh edition. London: The Louis Cassier Company, Ltd., Dorset House, Stamford Street, S.E.1. Price 25s.

Physical Similarity and Dimensional Analysis. By W. J. Duncan. London: Edward Arnold and Co., 41, Maddox Street, W.1. Price 30s.

Control of Raw Materials. By J. Hurstfield. London: Her Majesty's Stationery Office, Atlantic House, Holborn Viaduct, E.C.1. Price 35s.

The Measurement of Particle Size in Very Fine Powders. By H. E. Rose. London: Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 9s.

Strength and Testing of Materials, Volume VI of Selected Government Research Reports, in Two Parts. London: Her Majesty's Stationery Office, York House, Kingsway, W.C.2. Price (for each part) 55s.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LIBRARY SERVICE FOR INDUSTRY

SIR,—I learn from Mr. Hutchings' letter that librarianship is defined by the Council of the Library Association as consisting of "the selection, accession, organisation and exploitation of all forms of recorded thought." Are such exploiters of recorded thought as actors, doctors, historians, lawyers, lexicographers, musicians, patent agents, philologists, philosophers, politicians, publishers, and research scientists merely unqualified librarians, or is the definition perhaps unduly comprehensive ?

Whatever the faults of the definition, it appears to have the advantage of enabling those who accept it to claim any activity involving the use of records as librarianship. It certainly explains much that had seemed incomprehensible in this correspondence.

Should we not all do better to leave the slippery slopes of sterile semasiology and get on with our various jobs ?

E. B. UVAROV

Coventry, May 9th.

EDUCATION FOR DESIGN

SIR,—Your editorial and the excellent article by Professor M'Ewen on the education of engineers, both in your issue of May 22nd, have once again brought into sharper focus the perennial problem that vexes all those deeply concerned with the well-being of industry. As one who has been associated with the drawing-office and the design department, I am able to concur heartily with many of the views expressed.

There is, however, an underlying assumption in both statements which I venture to suggest is not warranted by the facts. This has resulted in not quite accurate conclusions being drawn from the comparison of university and school education. It is a psychological fact that, given certain innate qualities of mind and body, the student will rise superior to almost any unfavourable environment and this includes systems of education. Consequently, it is unwise to deduce too much from the example quoted by Sir David Pye, where the spirit of design was rampant amongst those who had entered industry direct from the school. Heredity and not education should perhaps be given the greater credit.

This distinction having been understood, I believe the main problem can then be more accurately diagnosed. As the function of designing is only one of several aspects of engineering, it should be the principal aim of university education to train the student to develop his own powers of thought. This is undoubtedly a trite statement ; it is withal axiomatic. The specific training of engineers who have an inner urge towards design should be covered by post-graduate courses at the universities and the technical colleges, and the training should be given by men who have the requisite engineering experience, as well as the ability to impart instruction.

S. C. MCKENZIE

Rugby, Warwickshire,
May 25th.

OIL CONSUMPTION FOR 1952.—Statistics relating to consumption and refinery production, published by the Petroleum Information Bureau on behalf of the Petroleum Industry Advisory Committee, show that Great Britain used more oil in 1952 than in any previous year, the total consumption being 17,520,145 tons. The principal items making up this total were : 5,440,552 tons of motor spirit, 3,456,832 tons of fuel oil, 1,641,362 tons of gas/diesel oil, 1,443,173 tons of kerosene, and 1,180,440 tons of diesel oil for road vehicles. The figures quoted show a drop in the consumption of motor spirit and an increase in the use of diesel oil for road vehicles, while the consumption of kerosene reflects the growing use of oil in agriculture. The effect of the refinery expansion programme is indicated by the output of products, which rose by slightly more than 6,000,000 tons to a grand total of 22,490,363 tons, of which 10,097,836 tons was fuel oil and 4,935,418 tons was motor and aviation spirit.

Research versus Trial and Error

By M. L. MEYER, B.Sc. (Eng.), A.M.I.Mech.E.

The author discusses the virtues of trial and error as compared with research in bringing about engineering developments. He points out that research need not be expensive and gives examples of the simple equipment that can often be used. Particulars are given of the Post-graduate School of Applied Mechanics in the University of Sheffield and mention is made of some of the work carried out by students there.

TRIAL-AND-ERROR methods are essential for engineering progress and development. Not every decision in design or production can be made the subject of research inquiries, but, on the other hand, in certain branches of engineering, applied or even fundamental research is an indispensable prerequisite of technical progress and cannot safely be replaced by guesswork, however inspired. It may be that, on the strength of research done now, future generations will be so used to the new problems that their engineering intuition will again lead to reliable progress, but at present trial and error would seem too dangerous and costly in such advanced branches. Between these extremes lies the wide industrial field, where research on one hand and trial and error on the other are both possible means of technical progress and constantly compete against each other. In this field, research has to justify itself in terms of time and money spent against practical improvement found and information gained.

As compared with trial and error, research bears an initial disadvantage ; its very name seems to spell time and money spent with little certainty of practical success ; it may suggest tedious work, long reports, and argument meant to impress rather than to produce remedies to be applied immediately. Trial-and-error methods are more spectacular both in failure and success ; the money spent is bound to reappear in practical results, even though the only comforting thought after the event may be the well-worn "I told you so !" Yet, given that time and money spent and practical success obtained were equal with both methods, the approach by research would have the additional advantage of giving more precise knowledge about the various factors affecting the practical problem at hand. Engineering troubles usually occur in waves, and the rational solution of one problem may help in dealing rationally with the companion problems. Moreover, past research experience often suggests possible practical solutions applicable without further investigation. In fact, competition turns to co-operation when research experience provides a fruitful basis for further trial and error.

The industrial research engineer who is conscious of having to compete with the more direct application of trial and error will always look for the shortest and cheapest approach to his problem. He will first consider whether his problem or a similar problem has already been satisfactorily investigated in the large amount of research available in literature. If not, then he will inquire whether an intended experimental investigation cannot be undertaken at little cost on existing apparatus at a research institution within reach of his firm. Only if this proves impossible will he ask for facilities to conduct research on specially built equipment. Since practical problems rarely require intricate or novel methods of investigation and the accuracy required is often not critical, a rather rough and surprisingly cheap equipment will produce good results.

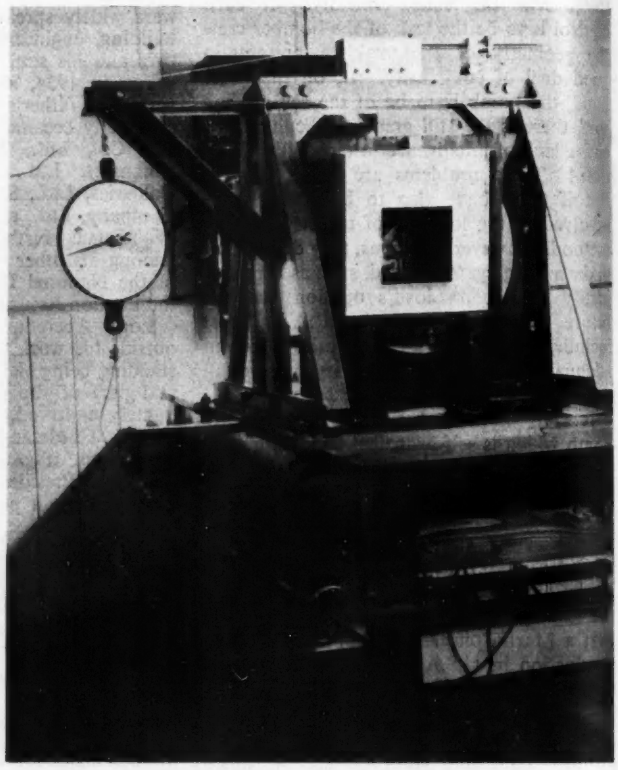


Fig. 1—Photo-Elastic Bench Without Lenses for the Determination of Maximum Stresses in "Corrected" Gear Teeth

To quote an example : a machine component has failed due to complicated overstressing. A strengthening of the part by the use of better steel seems too costly, a thicker cross-section of doubtful value. The research engineer will first peruse the *Proceedings of the Society for Experimental Stress Analysis*, where many complete stress analyses are described. He may then think of, say, a photoelastic investigation and approach a research institute, a university department, or even another industrial firm where a photoelastic bench is available. Only in the last

resort will he ask for experimental equipment to be bought or made. A 250W lamp, two polaroid plates and the transparent model material, a screening box and a stressing frame made in the shops, complete the most rudimentary photoelastic bench which may be mounted on a heavy table or stand. For more accurate results a mercury-vapour bulb with a green filter, or a sodium lamp and two quarter-wave plates may be added. The quarter-wave and polaroid plates are framed in a simple manner and mounted on wooden stands so that they can be rotated ; the photographic enlargement of a protractor provides the necessary angular scale (see

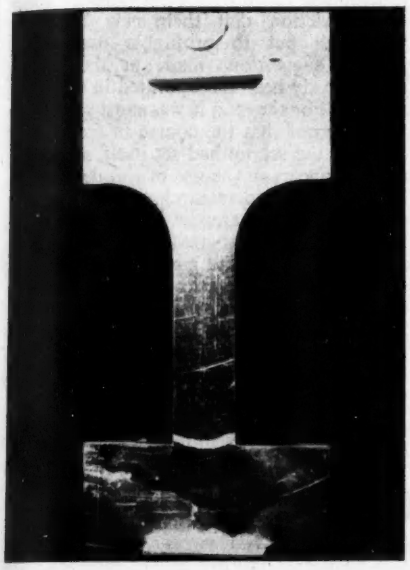


Fig. 2—Onset of Yield Observed by Means of Plumbers' Resin

Fig. 1). With this equipment and several comparative models of slightly differing shapes, the most favourable design for the machine component in question can be investigated quickly and systematically, yet the total cost may not be bigger than the cost of one failure by the trial-and-error method.

The simple equipment just described is well within the reach of the small engineering firm. So is an elementary equipment for static strain measurements with resistance-wire strain gauges ; it consists of a galvanometer or micro-amperemeter, a few accurate fixed resistances, a self-made slide wire, a car battery, the strain gauges, and a few inexpensive ancillary items. It is true that dynamic stress investigations require more expensive electronic equipment ; however, for one single investigation a fully equipped research department may offer help and for repeated use the equipment soon pays for itself, as dynamic problems do not readily lend themselves to successful trial-and-error attempts. These suggestions should not detract from the great value of proved commercial research equipment with its greater accuracy and ease and speed of handling. They merely serve to emphasise that there is no need to reject research because of the supposedly heavy initial outlay.

In purely mathematical research the cautious approach outlined before may help to shorten the tedious calculations required to solve complicated practical problems without too many simplifying assumptions. If literature shows that certain problems have been solved, e.g. by relaxation methods, it would be a waste of time to repeat the calculation. Connection with a university department may bring time-saving advice about the most suitable mathematical approach. Finally, although the student at school is expected to work out the one and only correct answer to a problem, the practising engineer only needs a sufficiently accurate approximate solution. Many approximation methods have been and are being developed in order to simplify and shorten calculations ; too often they remain unknown and unused. The numerical evaluation required by such methods can often be performed speedily either on the calculating machines of the firm's accounts department or on automatic computers which some universities, research institutes and firms hold available for these purposes.

The task of the research engineer who competes with the trial-and-error practician is not easy. He must see the practical implications of the problems he is called upon to investigate, propose research methods, estimate the time and money required and predict roughly the extent to which research results will be directly applicable in practice. He must approach existing literature with a quick critical eye, obtain and maintain connection with research institutions and university departments in his branch, and be able to apply experimental methods in the simplest possible form.

In order to provide the special training required for this industrial task, several universities have created post-graduate schools that offer full sessional courses (October to June) or courses of shorter duration to engineers with practical industrial experience likely to profit from the instruction and to graduates who intend to enter this particular field. The decision about the suitability of an applicant lies with the professor or director of the school ; a degree qualification is not necessarily required in the student. A few scholarships are often available. The number of students is usually small and the syllabus and practical instruction in experimental methods can therefore be adapted to a certain extent to individual needs. The student coming from industry can become thoroughly conversant with the research methods he expects to use in his firm and he may work on his own initiative, having regard to his firm's special problems. This is obviously possible only if each school deals with a strictly limited range of engineering subjects. Under the direction of Professor Tuplin, the Post-Graduate School of Applied Mechanics in the University of Sheffield, for instance, has restricted its syllabus entirely to problems arising out of the use of structural components in machinery. The broad subdivisions of the syllabus are (*a*) the elastic and non-elastic behaviour and strength of engineering materials, stress determination, selection of materials and design for welding ; (*b*) kinematics, including servo-mechanisms, vibration and noise problems, design and strength of gears ; (*c*) friction, wear and lubrication ; (*d*) subsidiary subjects indispensable for research into the main subjects, namely metrology, electronics, research photography, planning and reporting of research work.

The student takes about twelve lectures and six tutorial classes per week and devotes the rest of his time to laboratory work, which at the start acquaints him with various research apparatus and methods and later gives him scope for independent research work on some simple problem chosen by himself. At the start, for example, the student learns to affix strain gauges, develop electrical measuring circuits, check the quality of his fixing by calibration, and test the gauges to destruction in order to determine their mode of failure and limiting range. Various types of strain gauges are compared. In dynamic applications the student learns to sort out the most common troubles encountered with electronic apparatus. He uses vibration and noise analysers and takes and develops his own research photographs. A coat of plumbers' resin applied to a test piece is a very simple means of detecting the first traces of yield hence the points and directions of maximum stress under a given type of loading (Fig. 2). It is a useful preliminary test and shortens subsequent accurate investigations.

The student is taught to expect reasonable results at any stage of the experiments so as to check their arrangement. By comparison of various group experiments, probable error margins occurring under laboratory conditions and, more important, under industrial conditions are discussed. Later, each student chooses a minor independent research project likely to lead to some, at least preliminary, results in the time available. After reading existing literature, the student draws up a research plan and, after approval and thorough discussion, designs, builds or otherwise procures the required experimental apparatus. He is given the greatest possible freedom in his work and he is encouraged to keep in touch with his firm and to select his subject with a view to its potential usefulness after his return to the firm. In fact, maintained interest by firms that have sent students is fostered and the school was glad to welcome several directors of such companies during the last year.

Some of the work already undertaken may be of interest as showing the scope of the school. One student investigated photo-

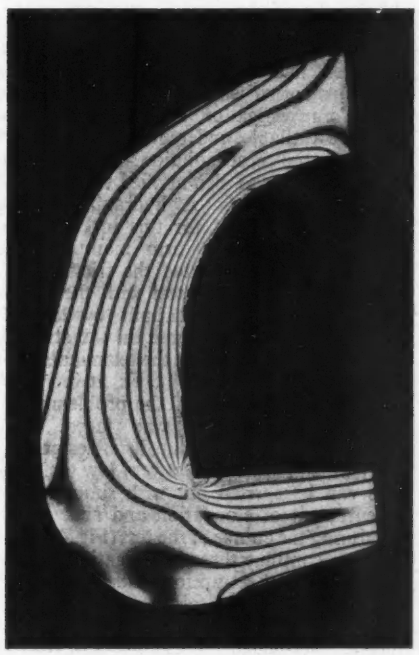


Fig. 3—Photo-Elastic Investigation of a Clamp

elastically the stresses in involute gear teeth cut according to a new system at present under consideration for a revision of the British Standards. This investigation will correlate the applied tooth load with the highest static local stress in any so-called " corrected " tooth and thus replace the present formula which refers only to teeth modified according to one particular rule. The simple photoelastic bench used for this research has already been mentioned (Fig. 1). The optical components were mounted as cheaply as possible, only the stressing frame was carefully designed for rigidity and

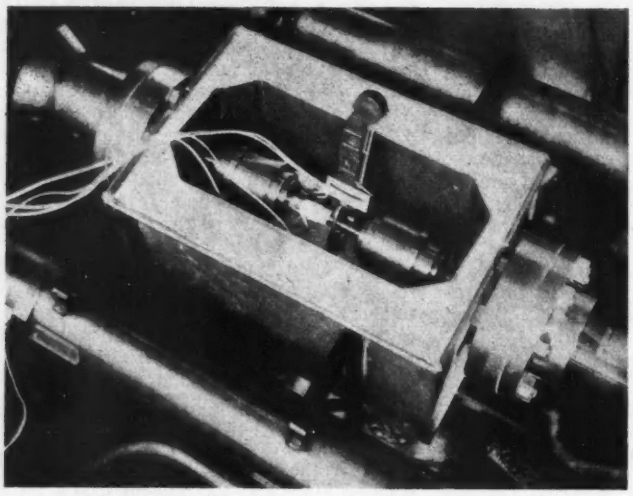


Fig. 4—Set-Up for Tension Tests at Very Low Temperatures with Simultaneous Measurement of Elongation

adjustability. The machining of the transparent models made of CR 39 resin is reputedly difficult and the student developed a simple and quick method which to our knowledge has not been used before ; the model is cut on the bandsaw to about $^{3}/_{64}$th of an inch filing allowance, then held horizontally against a short file mounted in a vertical spindle drilling machine. The direction of filing is along the edge and chipping is avoided ; the manually applied pressure regulates the local heat developed in the model.

Another student investigated a clamp (Fig. 3) which had caused service trouble in his factory. Fractures had occurred even when the dangerous corner was slightly radiused. The student's investigation showed that, within the space available, undercutting of the corner produced the best solution. The photo-elastic method was also applied to models of large press frames. A hydraulic loading frame was developed for this investigation. A student sent by a firm manufacturing stainless steel, investigated the friction properties of this type of steel with the aid of apparatus designed and built by himself. He took the M.Eng. degree on the strength of this work after passing the examination of the school. The use of metals at very low temperatures was one of the problems with which another factory was faced. The student coming from that firm designed a rig by which tensile tests at very low temperatures can be carried out with simultaneous measurement of elongation and area reduction during the course of the test (Fig. 4). It is hoped to continue these investigations with a slightly different set-up for welded specimens and at the same time to pursue more fundamental research on similar lines. Another student investigated the usefulness of electric resistance strain gauges at very low temperatures. Friction qualities of pearlitic cast irons, short-time notch fatigue tests, wear of pins, dynamic stresses in roller chains are other subjects chosen for investigation.

The full sessional course finishes with an examination for the diploma of the University of Sheffield. Since the school puts more emphasis on the application of knowledge than on memorising, the use of student's notes is permitted in this examination. Graduates of an approved university may use their independent research work as a thesis for the Master's degree, and in this connection attendance at the course is recognised for the purpose of a higher degree.

Five of the ten students who attended the first year's course at the school worked for a Master's degree; one student remained for another year with permission of his firm and is reading for the Ph.D. degree.

Since it is recognised that industrial firms can ill afford the absence of even one staff member for the full time, the syllabus will be slightly altered as from October, 1953. The intention is to divide the full course into five self-contained five-weekly sections, each devoted in the main to two special subjects. It will thus be possible for firms interested in certain special subjects to release a staff member for five consecutive weeks only, or different members of staff may attend different parts of the full course. Nevertheless, it is expected that some students will be able to attend for the full course, take the diploma or M.Eng. degree, and return to their firms with a wide and useful background knowledge of research. Research engineering requires not only knowledge of one or two methods of research, but a special attitude of mind which obviously will be developed to a greater extent by attendance at the full course with its variety of research subjects and by the more extensive interchange of ideas between students themselves and between students and staff working closely together.

The interest taken in the course became evident at a meeting held after the examination in June, 1952, at the suggestion of the students themselves. Though details of the course were freely criticised, the students agreed that it had shown them their industrial problems in a new light ; they also expressed the conviction that their new knowledge would be put to profitable use. Many positive suggestions made at the meeting have already been incorporated in this year's course. For the staff it was most pleasing to have a proof that the course in fact fulfilled the aims the school had set itself, namely, to train engineers in the use of simple, inexpensive and effective research methods, propagate a greater awareness of their usefulness for engineering progress, and in this way assist in bridging the gap between scientific research and its practical application under industrial conditions. Trial and error methods are unlikely to be superseded, but they will be made much more efficient if backed by the experience of an industrial research engineer.

Hanover Technical Fair

No. IV—(*Continued from page 727, May 22nd*)

CONTINUING our review of the recent Technical Fair at Hanover, we have chosen one or two examples of new designs from the section dealing with ceramic and clay-working machines.

In Fig. 20 we show a new design of clay-purifying machine which was exhibited by the firm of Soest-Ferrum G.m.b.H., of Düsseldorf-Oberkassel. Its purpose is to remove from raw masses of clay all small stones, organic matter and lime inclusions, which are unwanted in clay used for manufacturing purposes. The material entering the machine is taken up by a distributing roll, which is made of sheet rubber and is stretched over a revolving drum. The diameter of the drum is 1·60m, and various breadths can be supplied for different duties.

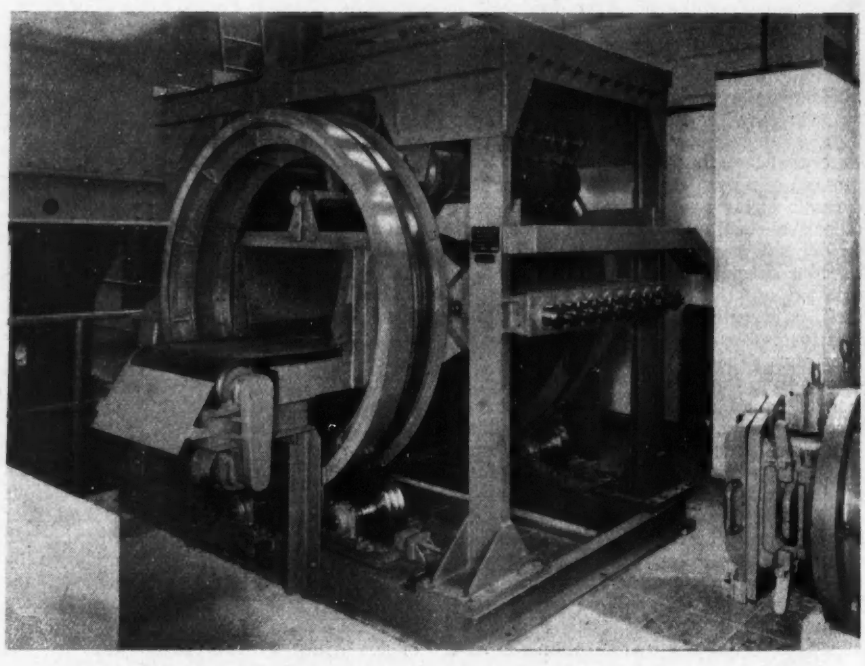


Fig. 20—Clay-purifying Machine—Soest-Ferrum

The drum is slotted, the distance between the lattice members being from 1·2mm to 1·8mm. These slots can be varied from 1mm to 4mm, depending upon the kind of clay inclusions which have to be eliminated. The clay distributed by the rubber roll passes on to a system of rubber-covered rollers which are staggered. These rollers feed the clay through the slots in the drum, and reject the hard inclusions, which are removed by a striking board.

Besides purifying the clay, the machine also prepares it by opening its texture. From the purifying machine a conveyor belt inside the drum takes the finished material on to further preparing machines, such as clay planers, &c. The same firm also showed a new design of vacuum pipe press for the making of large stoneware pipes, large porcelain insulators for electrical work, and certain forms of hollow bricks. In this machine the drive is arranged on the top platform and consists of an electric motor coupled to a three-speed gear by an electro-magnetic clutch. The mechanical mixing process kneads the clay until it is in a condition for the final pressing operation. The bottom table for receiving the pressed pipe is mounted on eccentric rollers and as the weight of the pipe increases the table travels down, and returns when the finished pipe is removed. For the larger sizes of presses the operation of the table is fully automatic for any desired length of pipe.

Another large plant for clay preparing was that which was exhibited by the Maschinenfabrik Güstav Eirich, of Hardheim, in North Bavaria.

It is shown in Fig. 21, and is essentially a mixing and kneading plant. The material is supplied to the machine by an automatic bucket conveyor which has a capacity of 1000 litres. It runs up inclined ways and tips the clay into the top of the machine. In the mixing and kneading process it is worked by means of elastically mounted blades on special rollers, the required quantity of moisture being obtained by the addition of water to the mass. On the left of our illustration there will be seen the two water tanks. On the ground below them is the electrical control switchboard. The switchboard has controls for the mixer, the conveyor bucket, the distributor and the water tanks, also the belt conveyors. After leaving the mixing and kneading pan, the clay passes downwards to a distributor, and finally to the extruding press at the bottom.

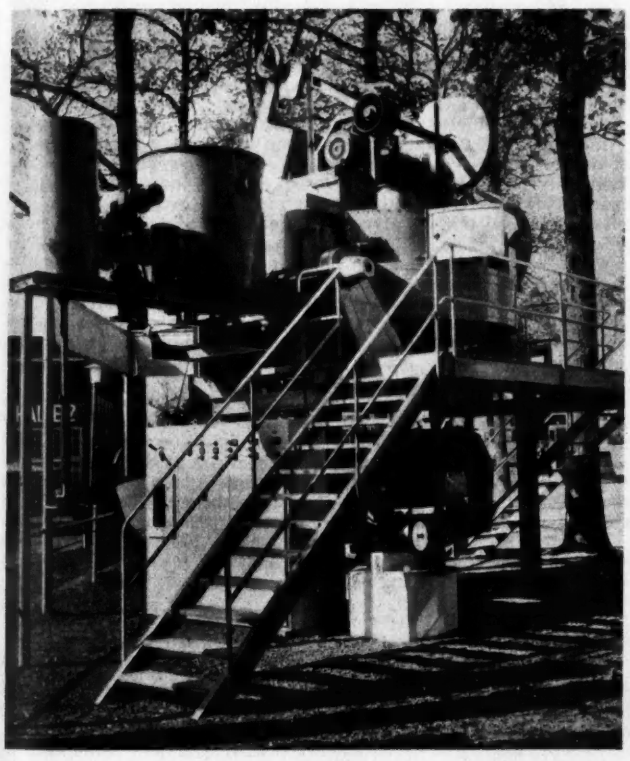


Fig. 21—Counter-Flow Mixer and Kneader—Eirich

The Maschinenfabrik Güstav Eirich is represented in England by the Orthos Industrial Trading Company, of 4, Mosley Street, Newcastle upon Tyne.

In the pump section of the Fair, an interesting exhibit was the new self-priming centrifugal pump (Fig. 22) for suction lifts up to 8m, which was demonstrated on the stand of Hammelrath and Schwenzer Punpenfabrik K.G., of Düsseldorf. The impeller is of open design and has only a small number of blades, so that it can handle effectively sewage and sludge, and heavy industrial liquids. As will be seen, the impeller casing is surmounted by a large rectangular casing carrying the inlet and discharge connections. It contains special air passages to mix the air and water, and at the same time it maintains a certain head of water above the impeller. The operation of the pump is fully automatic, and no foot valve or priming device is needed. The casing has large openings for cleaning. Any air in the suction pipe is taken up and mixed with the water and passes to the discharge outlet. The time for full suction is about three-quarters of a minute for a 3m lift, and about two and a half minutes for an 8m lift. The pump is designed to run at a speed of 1450 r.p.m. The bearings run in oil baths, and stuffing-boxes are fitted. These pumps can be supplied either for belt drive, as shown, or for motor or engine drive, or as a portable set on wheels.

On the stand of Pleuger and Co., of Hamburg-Wandsbeck, Friedrich Ebert Damm 101, various types of the firm's submersible and salvage pumps were shown. They all incorporate the "wet" motor designed by the firm, and are available in sizes from the smallest of 400 gallons per hour with delivery heights up to 500ft to the largest with an output of more than 100,000 gallons per hour. The "wet" motors are built in powers from 0·8 up to 450 h.p. There are two protecting rings welded on to the bottom and middle of the pump casing. They help to prevent the pump from sinking into mud or sand and can be used to roll the pump from one position to another during transport. "The Pleuger 2" salvage ship has been lent to the Dutch authorities to assist in the dewatering of flooded areas.

The latest application of the Pleuger "wet" motor is the "Active Rudder," which was shown at the last Marine Exhibition in London. It has now been successfully installed in the motor cargo ship "Irmgard Pleuger," a vessel of 2360 tons deadweight, which has served as a cargo-carrying vessel and also as a cable-laying and repair ship with the Norddeutschen Seekablewerk A.G., of Nordenham. The 125 h.p. "Active Rudder" has shown increased manœuvring powers with a single-screw ship, particularly in cable-laying operations.

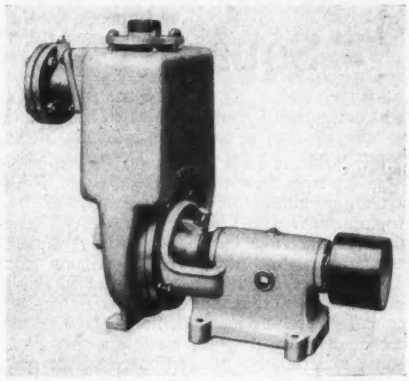


Fig. 22—Self Priming Centrifugal Pump—Hammelrath and Schwenzer

(To be continued)

An Instrument Firm's Centenary

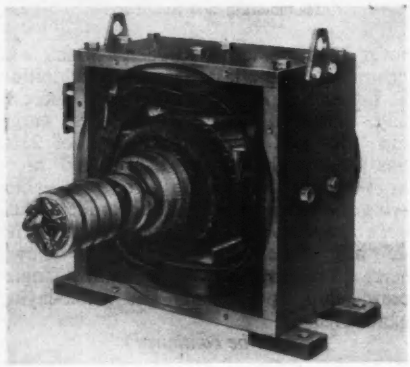
THE centenary of the foundation of W. F. Stanley and Co., Ltd., falls this year, and was celebrated with the firm holding an open day at its works at New Eltham, London, S.E.9, on Saturday last, May 23rd. The firm is well known for the surveying instruments, navigational instruments and drawing-office and mathematical instruments which it manufactures. A subsidiary company which occupies premises on the same site, Heath, Hicks and Perken (Thermometers), Ltd., is concerned with the manufacture of thermometers and barometers.

The founder of the firm, W. F. Stanley, set up in business in Holborn in 1853 as a maker of drawing-office equipment, but it was not until 1861, when he brought into use the first straight line dividing machine for dividing mathematical scales, a machine of his own invention, that the success of his business was assured. From that date the firm's activities expanded and became more varied, including successively the manufacture of metal drawing instruments, surveying instruments and so on. Stanley himself was very active as an innovator in all these activities, introducing many refinements and improvements, such as the first theodolite made by the firm which was much lighter and simpler than its contemporaries with about half the number of parts. He also wrote a number of technical books and presented numerous technical papers to learned societies during the course of his career. Geology and meteorology were amongst the many topics which he studied. He died at the age of eighty in 1909.

Since the founder's death, the firm has continued to expand its activities and has amalgamated with various other concerns. During a recent visit to the New Eltham works we were able to see the manufacture of a varied selection of instruments and equipment in progress, including the very accurate machines necessary for dividing theodolite scales, to give one example of the work in progress. Broadly, the various manufacturing processes carried out there may be divided into foundry work, optical work, general machining, glass-blowing, cabinet work and all the necessary processes of adjustment, assembly and calibration. The mathematical instruments made at the works include planimeters, moment integrators and harmonic analysers.

"Square-Path" Self-Regulating Alternators

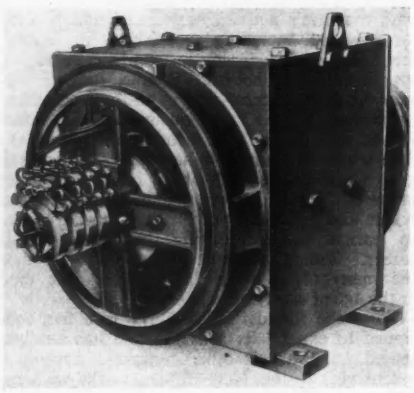
THE "Square-Path" alternator is the name given to a new range of self-excited, self-regulating alternators manufactured at the Hopkinson Works, Cardiff, of the Brush Electrical Engineering Company, Ltd. "Square-Path" alternators cover outputs ranging from 1½kVA to 35kVA. Electrically they resemble the company's existing design of circular-frame, self-regulating, self-excited alternators. On the mechanical side they represent an attempt to reduce material and production costs, the main departure from orthodox practice being the use



Magnet Frame, Field Coils and Rotor Assembly

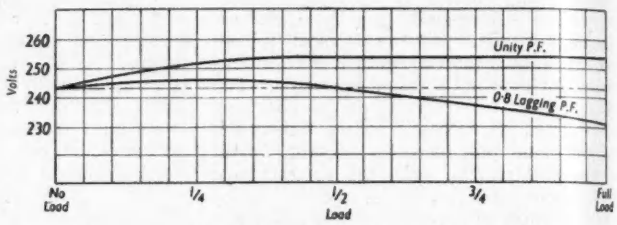
of a square magnet frame built up from flat plates as shown in our first illustration. An inherent voltage regulation of ±2½ per cent at 1·0 power factor is specified for the alternators rated at 1½kVA, 3kVA and 6kVA. For outputs above 6kVA inherent regulation is given as ±5 per cent at power factors between 1·0 and 0·8 lagging.

Basically the electrical circuit of the "Square Path" alternator remains similar to that of the earlier design with a circular frame. The revolving armature is provided with a commutator and brushgear for supplying the field excitation and with sliprings and the associated brushgear for the a.c. output. A normal shunt winding is connected across the main com-



Brushgear and Sliprings of Three-Phase, Four-Wire Alternator

mutator brushes and is excited at the full d.c. voltage to ensure rapid build-up of the open circuit voltage. Self-regulation is achieved by means of a low-voltage field winding carried on the main poles and supplied from a set of auxiliary d.c. brushes. This circuit gives additional excitation, increasing with the load, to compensate for engine speed reduction and for voltage drop normally associated with the application of increased load. Some improvements have been introduced to decrease the reactance of the a.c. winding, thus ensuring better performance with loads working at power factors below unity. Changes have also been made in the commutator and brushgear of the smaller machines to give improved commutation and greater reliability. By careful adjustment of the relative strengths of main shunt and auxiliary fields, greater stability has been achieved, particularly during the starting period, when the machine operates as a series motor. For starting the engine from a battery there is a series winding on the poles. In the earlier machines some reliance was placed on auxiliary field m.m.f. to assist the main shunt field at no-load, whereas in the "Square Path" alternator the open circuit excitation is derived entirely from the main shunt winding excited at or near the full d.c. generated voltage. Provision of a small trimming resistor in this circuit enables the open circuit voltage to be adjusted for variations in engine no-load speed. Further control settings are unnecessary, as the voltage-stabilising auxiliary circuit is designed to maintain the output voltage despite the 4 per cent speed drop of the usual prime mover when load is applied.



Design conditions: Unity to 0·8 lagging power factors; Nominal volts per phase 243; Voltage limits 255/231; Voltage regulation ± 5 per cent; Engine speed rise 4 per cent full load to no load

Typical Voltage Regulation Characteristics of "Square Path" Alternator

Typical performance characteristics are given in the accompanying curves. There is a slight rise of voltage to a maximum at about one-third of rated load when the machine is set for level voltage no-load and full-load. In the larger sizes, which cater for three-phase outputs at power factors ranging from unity to 0·8 lagging, the machine is set on test to give a rising voltage characteristic on unity p.f. loads, with a slight decrease of output volts for 0·8 p.f., as illustrated, but the overall voltage regulation can be maintained at ±5 per cent between these extremes.

The mechanical design of the new alternator is conditioned by the need for economising on the costs of materials and manufacture. As shown in our first illustration, the magnet frame is of square cross section, built up from steel plates. These plates are cut from flat mild steel strip on a power flame cutting machine, the length of the plate being adjusted to reduce the amount of metal left for removal in the subsequent machining process.

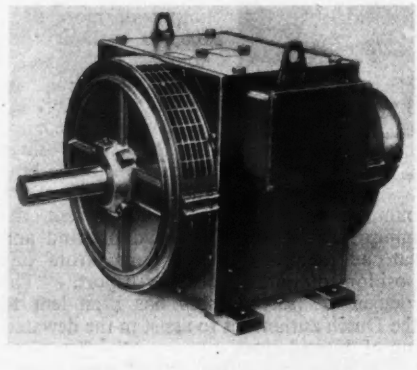
Flat plate has the advantage of being readily available and its use gives the designer considerable flexibility, without the limitations imposed by cast frames and the associated patterns. Moreover, simple jigs and fixtures can be used for assembling the magnet frames, the components of which can be gauged for rapid production.

The four plates making up each magnet yoke are jig-assembled to form a square frame and predrilled holes across the joints are finally reamed for dowels after bolting the plates together and before removing the yoke from the assembly jig. The only machining operation on the built-up yoke is the cutting of registers for locating the end shields. This method of fabrication reduces the labour involved in handling heavy magnet frames and effects a saving in floor-to-floor times.

The magnet poles consist of a body portion of circular cross section, welded to a prebuilt laminated pole shoe. The use of black mild steel bar, the simplicity of the pole machining, and the ease of producing field coils on circular formers are three factors that contribute to economies in material content and production costs. As the pole assembly is easily held to close limits, and internal faces in the frame structure are milled flat all over, the correct air gap is obtained without the need for shims or additional machining. The field windings are of polyvinalacetal covered copper wire wound on formers fitted with insulating flanges and held in position by the pole shoes.

The armature is of more orthodox design. Both the a.c. and d.c. windings are distributed in the same armature slots, the coils being of polyvinalacetal-covered copper wire, former wound. The commutator and sliprings are on the same end of the shaft as shown in the first illustration. The other photographs show a view of the slipring end of an alternator with the protective covers removed and a typical "Square Path" alternator with a standard screen protected enclosure. All the machines in the range are air cooled by a ventilating fan fitted to the shaft at the driving end, the fan being dynamically balanced with the armature. The armature shaft is carried on ball bearings housed in end shields spigoted to the magnet frame. The machines are designed to comply with B.S. 168.

"Square Path" self-regulating alternators are designed to be suitable for automatic or semi-automatic lighting sets and, as indicated above, they are provided with a series winding for starting the engine from a battery. Besides providing excitation the main field will supply current for battery charging. The 1½kVA machines are wound for 12V starting and charging and the 3kVA and 6kVA sizes for 24V starting and charging.



Screen Protected "Square Path" Alternator

SHUNTING LOCOMOTIVES FOR BRITISH RAILWAYS.—An order for fifteen power equipments for 350 H.P. diesel-electric shunting locomotives has been placed with the British Thomson-Houston Company, Ltd., by British Railways. This is part of the first order in a five years' programme which will increase substantially the number of diesel-electric shunters operated by British Railways. The mechanical parts for these locomotives will be made to standard British Railways designs in the railway workshops; the order for power equipments has been divided between four electrical manufacturers. The engine being supplied with the B.T.H. equipment is the Blackstone type ERT6, rated 350 h.p. at 750 r.p.m. It is coupled to a B.T.H. main generator which is a single-bearing machine spigot mounted on the engine. The exciter and the 10kW auxiliary generator are mounted on, and belt driven from, the main generator. The three axles of the locomotive are coupled together and are driven by two geared axle-hung motors which are force-ventilated by a centrifugal blower. The equipment includes a Westinghouse exhauster driven by a B.T.H. motor and a Westinghouse compressor with integral motor.

Aero-Engine Noise*

By F. B. GREATREX, B.A., A.M.I.E.E., A.F.R.Ae.S.†

THE title of this paper could cover a number of interesting problems ranging from the ultrasonic scream from compressors and its (alleged) effect in producing "jet sickness," to the noise from supersonic propellers, but, since it is "in particular jet noise" which is under discussion, this paper deals entirely with that subject. Some new facts are presented, mostly obtained at my own firm, with the active encouragement of the Ministry of Supply, and some of their implications are discussed.

THE NOISE FIELD ROUND THE JET FROM A JET ENGINE

A very complete set of noise measurements has been made round a Derwent engine mounted on a special test bed out in the open, over a wide range of revolutions per minute. Some of the results are shown as noise contours round the engine running at its maximum continuous revolutions per minute for seven out of the eight octave bands of a Standard Telephones analyser (the highest frequency band was faulty at the time of the test). Very similar contours have been obtained round an "Avon" engine, and also round some American engines, so that the general pattern of noise appears to be independent of the type of engine, as one would expect if it is entirely due to the interaction of the high velocity jet with the surrounding air.

COMPARISON WITH MODEL JETS AND WITH THEORY

The variation with frequency of the angle at which the peak noise occurs is generally very similar to the variation obtained on model tests, the actual figures being 14 deg. from the jet centre line in the 37·5–75 cycle band, varying round to 70 deg. in the 2400–4800 cycle band. The apparent source of the noise also seems to be further downstream at the lower frequencies, as in the model tests.

The loudest noise appears to occur at approximately 30 deg. to the jet axis. A point on this 30 deg. line, at 20 yards radius from the jet nozzle, has therefore been chosen for more detailed investigation of the available results. The overall sound intensity at this point, summed over the whole frequency band, has been plotted against the jet velocity for the "Derwent" and "Avon" engines mentioned above, and also for a larger engine of 9000 lb thrust rating, and (a single point) for a "Nene" engine. The results throw some interesting light on the main points of the Lighthill theory :

(1) The theory implies that the noise produced by a jet is independent of the jet temperature, and model tests have supported this. In these full-scale tests jet temperature variations over the measured range of revolutions per minute of 145 deg. Cent. for the "Derwent," and 70 deg. Cent. for the "Avon," have not produced any deviation from a straightforward power law relationship between noise and velocity.

(2) The results concerning this power law relationship are particularly striking ; the index is exactly 8 for the "Derwent" results, agreeing precisely with the theory. In the case of the "Avon" and "9000 lb thrust" engines, the same power law gives a very good fit with the points. This is particularly interesting as the top "Avon" point, and the top two "9000 lb thrust" engine points are at jet pressure ratios well above the critical.

Any shock wave phenomena that may be occurring do not seem to have had any appreciable effect on the noise. It is clear that subsonic laws can be used to predict ground running noise even though the critical pressure ratio is exceeded.

(3) The theory predicts that the noise should vary as the square of the jet nozzle diameter. The appropriate correction for this is nothing like sufficient to account for the difference between the engines—there remains up to 7 db "error." This is disappointing, but as the measurements were made under different conditions (only the "Derwent" measurements were made on a testbed designed specially for noise work) and with different noise analysers, it is perhaps better not to draw any hard and fast conclusions on this point.

The lines through the points have been extended up to the jet velocity corresponding to the maximum take-off revolutions per minute in each case, so that the maximum noise levels to be expected with each type of engine can be read off the graph.

REHEAT

It is clearly high jet velocity which is the real culprit in producing noise. It is therefore unfortunate that one of the most useful methods of getting a large thrust out of a small engine, by the use of reheat or after-burning in the jet pipe, depends entirely on increasing the jet velocity.

Consider a series of engines, starting with one having a total temperature in the jet of 600 deg. Cent. Keeping the pressure ratio, and hence Mach number in the jet constant, and by burning increasing amounts of fuel, the temperature T in the jet is raised so that the velocity V increases as $\sqrt{T}$, but the thrust is kept constant. It is an extravagant process ; the amount of fuel needed to produce the given thrust increases very rapidly. But the hotter engines are smaller, (and this, of course, is the great advantage to the aircraft designer of this type of engine). It turns out that the jet nozzle diameter remains constant for this series of engines so that the noise should increase as V^8, i.e. T^4.

In practice, of course, reheat is applied to an actual engine, increasing the nozzle area so that the air flow is maintained constant. Nozzle area and thrust then increase in proportion, by about 70 per cent in the limiting case, producing a further contribution to the noise of 2½ db (accepting the Lighthill theory). Thus the maximum possible increase of noise due to applying reheat to an existing engine of this type is about 21 db. This would give an overall intensity at 20 yards radius and 30 deg. angle of 160db on an "Avon."

The effect of reheat on noise can be expressed in another way—if an increase in thrust is obtained by reheat the noise is increased as $(\text{thrust})^9$, whereas if the same increase in thrust is obtained by building a larger engine the noise is increased simply as the thrust.

There is another aspect of the problem which should just be mentioned, as it is already causing trouble on some aircraft even without reheat—that is, that minor structural fatigue failures can occur due to vibration caused by pressure fluctuations from a jet. Obviously this trouble will be greatly intensified by the use of reheat.

Fortunately, in so far as it concerns noise and vibration, those very large thrust increases are still unrealised in practice. First, due to the obstructions required in the jet pipe to produce stable combustion, the jet velocity and, hence, the thrust, are less than the theoretical figure, and, secondly, the highest temperatures so far attained are very much less than the theoretical maximum.

There is some practical evidence concerning reheat which supplies further confirmation of the Lighthill theory. It is extremely interesting to note that the increase of noise due to reheat is no greater than the figures which have been predicted on the assumption that there would be no change in the degree of turbulence in the jet stream—for there undoubtedly is a considerable increase in turbulence in the main stream, though probably not in the boundary layer in the jet pipe. Is it perhaps only the turbulence in the boundary layer which affects the noise production ?

It is clear that the use of reheat presents a truly formidable problem in its associated noise, which must be mastered so that its performance advantages can be effectively used, at least on military aircraft.

NOISE REDUCTION METHODS

So much for the problems ; are there any cures in sight ?

First, of course, there is the possibility of designing an engine from the start to use a lower jet velocity. A practical value of temperature is 400 deg. Cent., and the consequent reduction in noise is about 4 db.

But it must not be thought that it is only the stupidity or obstinacy of engine designers which prevents this "silent" engine from being made. The real drawback is that a low-temperature engine is inevitably larger. Since the main advantage of a jet engine is its lightness, very solid arguments are needed to support a case for a heavier engine, in spite of its reduced fuel consumption. Fortunately, the large civil jet airliner, for which noise levels must be much less than for military aircraft, is just the right application for an engine of this type. Such an engine already exists, the "Conway," and it is hoped that measurements shortly to be made will confirm the expected reduction in noise.

Secondly, there are a number of additive devices which have been found to give substantial noise reductions when tested on model jets at Cranfield, Manchester and Southampton. The most promising of these, at any rate for the mainly subsonic jet speeds in which we are interested for ground running, consist of "teeth" attached to the jet nozzle, either parallel to the jet axis or bent inwards.

At high revolutions per minute the teeth are remarkably effective in reducing the low-frequency peak noise near to the jet axis, a reduction of some 8 db to 10 db being obtained, but the high-frequency peak at around 90 deg. is actually increased.

This result seems to conflict with expectations in that it is the low-frequency noise which is reduced, the noise thought to be generated by large eddies downstream of the nozzle and not affected by details of the nozzle shape. The noise reduction of 8 db to 10 db is also appreciably greater than that obtained in the model tests in this subsonic speed range.

This noise reduction was obtained with negligible effect on engine performance ; the only measurable change was a very slight increase in jet pipe temperature, thrust and fuel consumption being apparently unaffected.

The summed noise intensity at the 50ft radius/30 deg. point has been plotted against jet velocity. The noise reduction appeared to be effective only at high jet velocities. This suggests that it would not be possible to improve on our low jet velocity engine by means of this device, but that it should certainly be effective with reheat.

Summing up, it appears that a simple device is available which will markedly reduce the low-frequency noise from a high (subsonic) velocity jet, although the mechanism of this reduction is not really understood, at negligible cost in engine performance and at the expense of some increase in high-frequency noise.

It is pleasant to be able to end on this optimistic note, but the optimism must be slightly qualified by the warning that these noise reduction devices may have other troubles associated with them, such as the more rapid spread of the jet found from model tests, which have not yet been properly explored.

* Abstracts, Joint Symposium of the Royal Aeronautical Society and the Acoustics Group of the Physical Society, May 21st.

† Rolls-Royce, Ltd.

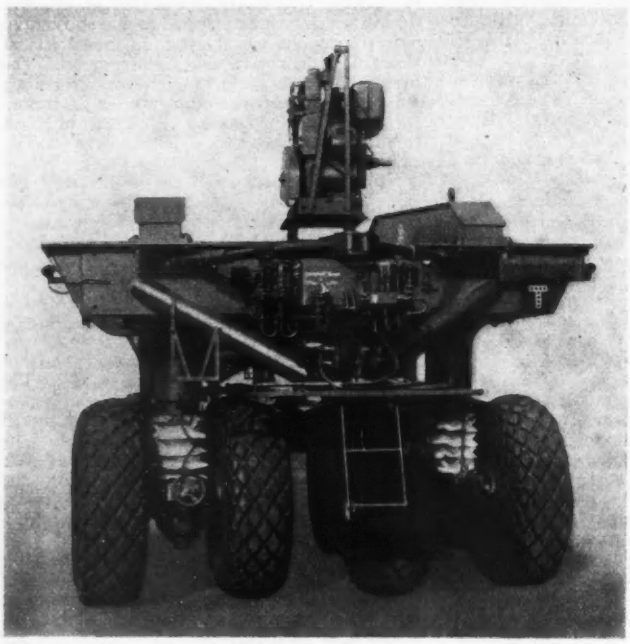
Mineral Output in North Rhodesia and Tanganyika

THE total mineral output in Northern Rhodesia last year was valued at more than £97,000,000—an increase of some £7,000,000 on the value of the 1951 output, according to the Department of Mines in Lusaka. Blister copper and electrolytic copper production in 1952 amounted to £72,224,000.

In an article in the *Industrial Review* it is stated that all records for mineral production were broken in Tanganyika last lear. The provisional value of exported minerals is placed at a little over £6½ million and the value of minerals used locally is not far short of £300,000. The export figure, however, is undoubtedly heavily inflated due to the disposal during the year of the backlog of diamond production accumulated by Williamson Diamonds, Ltd., during the greater part of 1950 and the whole of 1951, during the dispute between Williamson Diamonds and the Diamond Corporation. It is estimated that had exports been normal the export figures would have been something under £4 million, but even that would have been a new record.

A 120-ton Trailer

A TRAILER of 120 tons capacity has been designed and built by Cranes (Dereham), Ltd., of Dereham, Norfolk, for the transport of heavy equipment in connection with the Snowy Mountain hydro-electric scheme in Australia. As can be seen from the illustrations on this page, the trailer consists essentially of two identical eight-wheeled bogies connected by a heavy frame. It has hydraulic suspension, a hydraulic jacking system and a hydraulically operated steering system.



Trailer Bogie Unit

Two frames are provided, that illustrated being the low loading unit, which is connected to the bogies by means of swan necks. The low loading frame can be disconnected from the swan necks for loading and off-loading purposes and the frame has a clear load length of 30ft. By means of alternative tubular cross members fitted between the main longitudinal members the frame width can be adjusted to 4ft 6in, 7ft, 8ft 6in or 11ft. The alternative frame consists of two main longitudinal members, which, when the swan necks are removed, rest on the tops of the bogies to which they are bolted. This frame is used to carry large high loads "sedan chair" fashion, and it can be fitted with tubular cross members of different lengths.

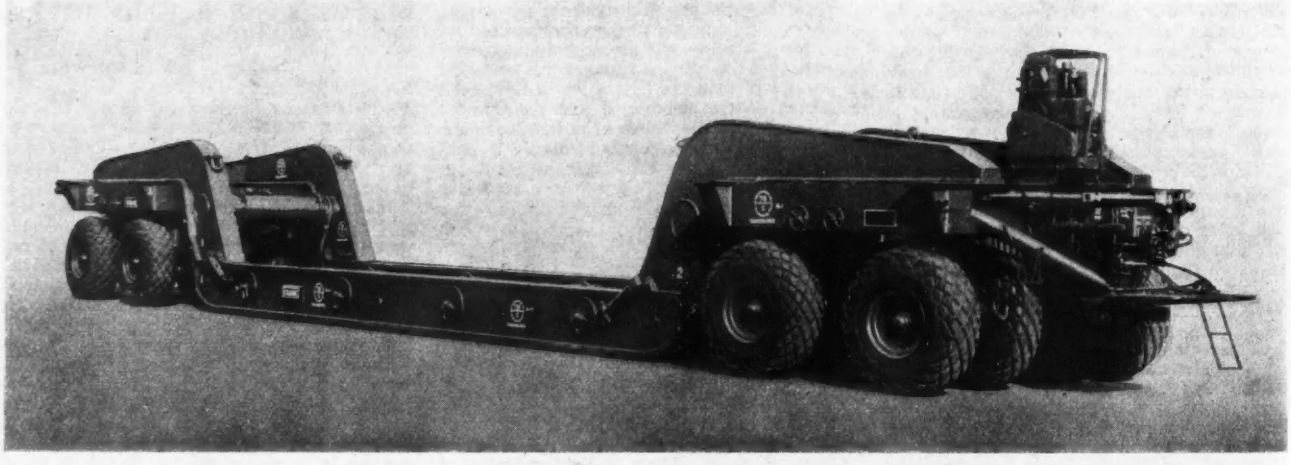
Each of the bogies is carried on eight 16·00 by 20, twenty-four-ply pneumatic tyres, mounted on four short axles. These axles are pivoted at the centre in order to allow individual wheel movement to uneven ground conditions. Over the centre of each axle there is a 9in diameter hydraulic ram assembly by which it is coupled to the bogie frame. The rams can be raised or lowered as required to lift or lower the load for it to clear railway arches or to pass over humpbacked bridges. This hydraulic system can also be arranged to be self adjusting so that there is a flow of fluid between the front and rear cylinders to equalise the loading on each tyre. In these units the plunger movement is simply a sliding one, as the cylinders are arranged to rotate with the axles when necessary for steering purposes.

Both bogies can be steered in any direction at the same time, and the four axles of each bogie can be caused to turn through 90 deg. in either direction by a second hydraulic system or by drawbar control. Generally the rear end of the vehicle will be separately steered by a man riding on a small platform on the extreme rear, where simple controls are arranged to bring hydraulic steering cylinders into action by the movement of one of a pair of three-way valves. Each of these valves operates a double-acting cylinder.

It should be understood that the four axles can pivot simultaneously through 180 deg., and this movement is made possible by a system of chain steering, which couples all four cylinder heads together and is operated from the drawbar post. Both ends of the vehicle are identical, the front ends being steered as well as towed by a triangular drawbar, but the rear is steered either by a tractor or by hand controlled hydraulic gear, as already mentioned. It is interesting to note that the vehicle can be turned completely round within a circle of 68ft diameter or approximately its own length, or it can be moved bodily sideways by the use of two tractors.

Each bogie is equipped with a high-speed pump capable of delivering fluid at a pressure of 1750 lb per square inch, and which can be quickly brought into use to operate either the steering or the axle cylinders. The hydraulic unit pumps are motor driven and when loading or unloading takes place at a site or power station a connection to the electric mains can easily be made. When on the road a small diesel engine-driven generator is used to supply power for operating the pump motor. In the illustration showing the bogie unit the generating set, hydraulic steering controls and axle suspension arrangements can clearly be seen.

A pair of 15½in diameter, 7in wide Girling brakes fitted on each axle are arranged for air cylinder operation. The brake cylinders are operated through a special Bendix Westinghouse two-pipe line system and all sixteen wheels of the trailer can be braked from either end simultaneously. A mechanical brake application can be made by means of a handwheel.



Trailer With Low Loading Frame

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

BRASS TUBES FOR GENERAL PURPOSES 70/30 BRASS, ALUMINIUM BRASS

No. 885 : 1953. Price 2s. 6d. In this revised standard, which replaces the 1940 edition of B.S. 885/6, requirements for both as drawn and annealed tubes previously numbered separately as B.S. 885 and B.S. 886 have been incorporated in the one publication. The optional addition of tin to 70/30 brass has been deleted and aluminium brass has been included as an additional alloy. Many clauses have been redrafted and certain modifications made to the tests required and tolerances allowed.

An appendix includes a table of sizes of 70/30 brass and aluminium brass pipe for the petroleum industry.

THERMOSETTING SYNTHETIC-RESIN-BONDED PAPER ROUND TUBES FOR RADIO FREQUENCIES

No. 1951 : 1953. Price 2s. 6d. The above standard is one in a series dealing with synthetic-resin-bonded paper materials for use as electrical insulation. It specifies the requirements of two grades of circular cross-sectioned tubes for use at radio frequencies and in this respect is complementary to B.S. 1314 : 1946 and to B.S. 1885 : 1952, which cover, respectively, circular and rectangular cross-sectioned synthetic-resin-bonded paper tubes for electrical power circuits. Requirements for tubes up to 1in external diameter are specified, and the electrical and physical properties covered include power factor and permittivity, insulation resistance along laminæ, density, water absorption, cohesive strength between layers, and dimensional tolerances. Methods of test to check compliance with the specified requirements are fully described in appendices.

The Nechako-Kemano Hydro-Electric Scheme in British Columbia

No. I

A hydro-electric scheme with an ultimate firm power output of about 1200MW is at present under construction in British Columbia. The work at present in progress includes the installation of three vertical single-runner impulse turbo-alternator sets, each of about 105MW capacity, and the construction of a transmission line of considerable ultimate capacity between Kemano power station and the site of a new aluminium works at Kitimat. The principal impounding structure, a rock-fill dam with a height of 317ft, was completed last year.

IN our annual review of foreign civil engineering schemes published in THE ENGINEER of January 30th last, a brief mention was made of the Nechako-Kemano hydro-electric scheme in British Columbia. Some further details of this scheme are given here, based upon a paper by Mr. F. L. Lawton, chief engineer of the power department of Aluminium Laboratories, Ltd., Montreal. The scheme is of particular interest on account of the large ultimate production of power which may be obtained from it, and also because of its general layout, for which an underground power station has been adopted, following Continental rather than North American practice. The power generated by the scheme is to be consumed in an aluminium reduction plant at present under construction at Kitimat. The projected works include a town and harbour at Kitimat, and transmission lines over the difficult country between the power station and Kitimat.

The hydro-electric scheme itself is of basically simple layout, consisting of a large storage reservoir, a diversion tunnel, and underground penstocks and power station, with the tail-race discharging into the Kemano River. This layout may be better appreciated by reference to our illustration below. The right-hand illustration shows the general position of the scheme, and the lower one shows the extent of the hydro-electric works. As may be observed, the reservoir is formed by enlarging a number of existing lakes by the construction of the Kenney dam at the natural outfall of these lakes on the Nechako River, and by a number of small subsidiary dams at other points round the reservoir. These impounding works enable the run-off to be diverted into Tahtsa River and Tahtsa Lake, full reservoir level being 15ft above Tahtsa Lake, at the opposite end of the catchment from the natural outfall, and thence through the diversion tunnel to the power station. The lakes forming the reservoir are typical of the glacial formations of British Columbia. The catchments of the Nanika and Kidprice lakes is to be diverted into Tahtsa Lake at a later stage in the project, to increase the ultimate production of power.

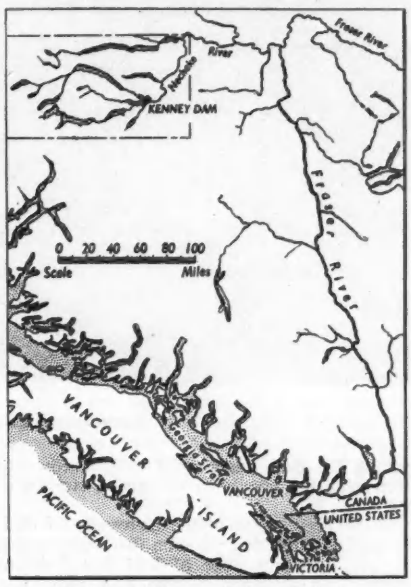
Flow statistics for the scheme are given in the table overleaf. The ultimate installed capacity of the power station will be about 1680MW (which, amongst existing hydro-electric schemes, is exceeded only by the installation at Grand Coulee dam) with a firm power output of about 1200MW. At present three similar turbo-alternator units, totalling 314MW, are being installed for completion in 1954, and one of the two diversion tunnels from Tahtsa Lake to the power station is being built. Apparently future expansion to the ultimate capacity will be dictated by the needs of the aluminium industry, and in particular by the production of aluminium at Kitimat, where it is intended to install what is thought to be the world's largest aluminium smelter. As mentioned in our earlier article, the main dam had been virtually completed at the end of last year, 4 miles of the total length of 10 miles of the diversion tunnel had by then been driven, and about half of the excavation for the power station had been completed.

KENNEY DAM

The Nechako River flows to the north through a volcanic ridge standing 1000ft above the plateau, at the site chosen for the Kenney dam. The strata of the canyon at the dam site are nearly horizontal, dipping slightly downstream. A felspar prophyry dyke underlying relatively weak volcanic tuffs and similar rocks forms an effective cut-off just upstream of the dam site.

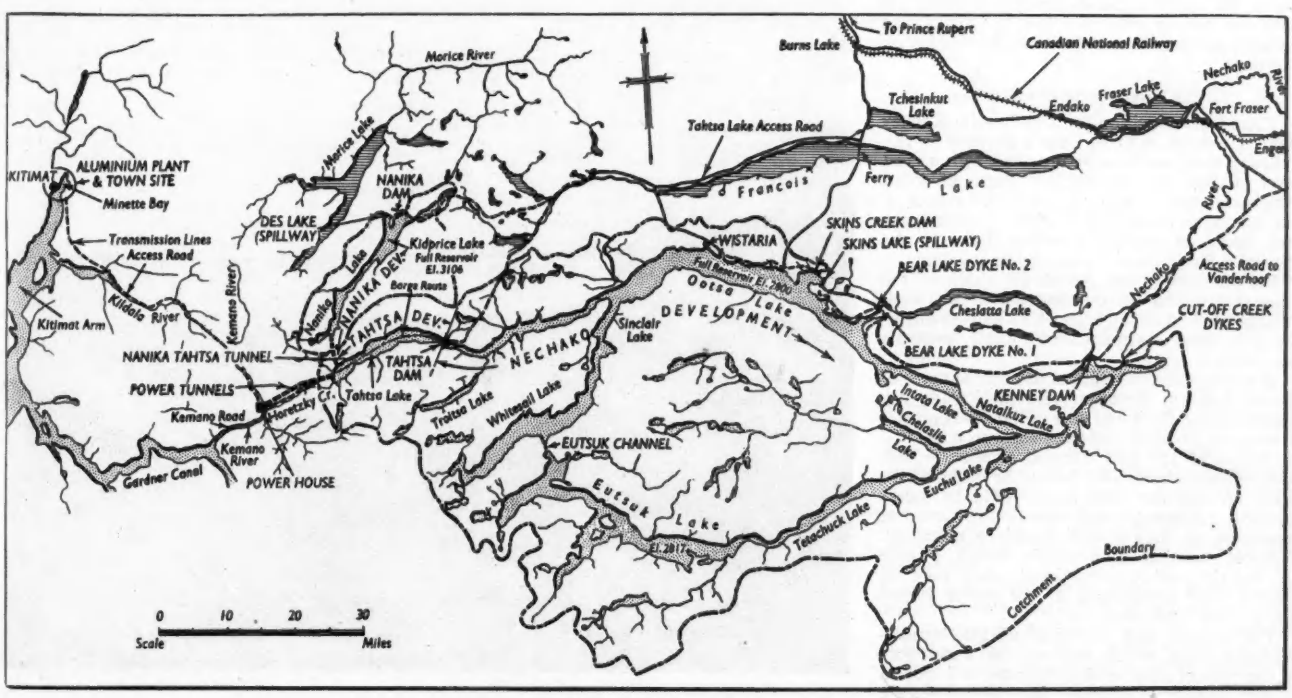
The dam is a rockfill structure supporting on the upstream slope an impervious section of rolled-earth construction held between suitable filter layers. The impervious core extends from near the top of the dam to a cut-off trench in sound rock, below which effective cut-off is ensured by a grout curtain, the upper 25ft of rock being grouted at pressures of about 20 lb per square inch, with deep holes cutting the consolidated upper zone grouted at higher pressures.

The dam has a maximum height above bed-rock of about 317ft and a crest length of about 1550ft. The freeboard at the abutments is 12·5ft with a superelevation of 5ft at the centre of dam



Position of Kemano-Kitimat Project

to allow for settlement. The normal maximum reservoir level is 2800ft, but a flood surcharge of 7ft has been allowed. The crest width of the dam is 40ft and the slope of the upstream face is one vertical to 2·5 horizontal. The slope of the downstream face averages 1 : 1·75 (1 : 1·4 is the natural angle of repose of the rock when dumped and sluiced) over a number of 1 : 1·4 slopes and berms. The formation of the dam was trimmed to slopes not exceeding 1 : 1·5 to eliminate the possibility of tension cracks in the impervious core due to differential settlement. The longitudinal axis of the dam has been given a slight camber upstream, thus



The Kemano-Kitimat Project

Construction of Kenney Dam in Progress

putting the core under axial compression and decreasing the possibility of tension stresses in the core.

Model tests, made at the University of California, indicated that the dam (with crest width of 30ft, upstream slope of 1 : 1·5 and downstream 1 : 1·4) would be free from movement (sliding) with a pressure on the upstream face of over ten times that arising from the water load. Shaking-table model tests showed the dam would be safe with an acceleration equal to gravity, although the dam is not in a seismically-active area.

Materials for construction of the dam were obtained from adjacent quarries and borrow areas. About 3,700,000 cubic yards of fill was used. Unwatering of the site was effected by a diversion tunnel in the left bank, completed during 1951. This tunnel is of horse-shoe cross-section, 32ft diameter and about 1430ft long, with a slope of 0·0135, and was eventually closed by a concrete plug below the impervious core and grouted zone. The rockfill cofferdam below the tunnel entrance portal and above the dam site had its crest at a level of 2590. The Kenney dam is shown in the two illustrations on this page.

Other Impounding Structures

There is no provision for a spillway at Kenney dam. However, at Skins Lake a concrete gravity spillway structure is to be provided with a crest level of 2800 and an effective length of 457ft, which will have a capacity of 30,000 cusecs at the maximum flood level of 2807. This spillway will discharge through Cheslatta Lake to the Nechako River about 5 miles below the dam.

Various low points round the shore of the reservoir require the construction of six small rock or earthfill dykes, each with a sloping impervious core and constructed from locally available materials.

In order that most efficient use can be made of Tahtsa Lake in the event of a particularly dry season during the initial year of the development, a temporary rockfill embankment with a hydraulic height of 15ft and a length of about 1500ft may be built about 300ft below the outlet of the lake. A spillway 250ft long would be incorporated. Although rock foundations are not available, no deep cut-off would be necessary. Suitable material is available within ¼ mile of the site and constructional work may be started after completion of the power tunnel portals and intake structure.

The storage and diversion of the Nanika-Kidprice lakes, which will not be undertaken at the present stage of development, will require a dam similar to Kenney dam, about ½ mile below the outlet of Kidprice Lake. This dam will have a maximum height of about 155ft and a crest length of about 800ft, the volume of all fill in place amounting to about 500,000 cubic yards. To handle flood waters from the Nanika-Kidprice diversion a low concrete spillway will be constructed at the westerly end of Des Lake, the discharge returning to the Nanika River, several miles below the storage and diversion dam. The crest of the spillway will be at normal full reservoir level of 3106.

Water will be diverted from the Nanika-Kidprice watershed by driving a tunnel 3·8 miles in length and with a 13ft equivalent diameter from the Tahtsa portal. Its invert at the Nanika Lake inlet will be positioned to carry the maximum natural outflow and maintain reservoir level at the Des Lake spillway crest at 3106ft.

In order that water can be drawn through the Tahtsa River from the Nechako reservoir to Tahtsa Lake and thence to the power tunnels, it will be necessary to excavate, depending on power requirements, the 3-mile stretch of Tahtsa River immediately below the outlet of Tahtsa Lake to a depth of about 40ft.

Power Tunnels

Two power tunnels, each about 10·1 miles in length, unlined and with concrete inverts, will be necessary for the complete development of the scheme. One of them is at present under construction. The intake works will be of concrete and will stand about 1000ft west of Penteuch Pass Creek, and a channel about 80ft wide at the invert will be cut from this point to Tahtsa Lake. The intake includes trash racks, bulkhead guides and two fixed-wheel gates, 14ft by 26ft in size. The invert level of the power tunnel near the intake structure is 2718ft, the gate sill for No. 1 tunnel being at 2725. When tunnel No. 2 is built the invert will be at 2740ft. The tunnel invert will be at 2591ft at the surge chamber.

The design followed that of tunnels in the U.S.A., from which a friction factor from Kutter's formula of $N=0·040$ was taken for unlined tunnels, and $N=0·014$ for lined tunnels. Friction losses and tunnel costs were based on the use of steel supports and 18in concrete lining for 10 per cent of the total length, where required, for support or to cut off influxes of water. The nominal sizes of the horseshoe cross sections

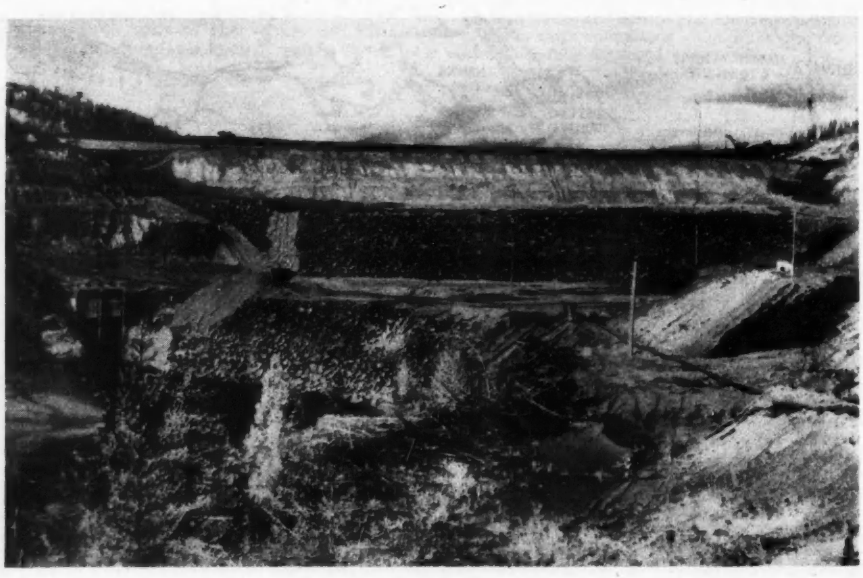
Hydrological Data for the Nechako-Kemano Hydro-Electric Scheme

Catchment	Average flow over twenty-year period	Estimated regulated flow available for power production
	Cusecs	Cusecs
Tahtsa	940	925
Nechako (excluding Tahtsa)	5555	5075
Nanika-Kidprice	975	920

Average reservoir level above sea level ...	2795ft
Capacity at reservoir level of 2800	19,400,000 acre-feet
Storage of first stage of scheme	230,000 acre-feet
Average gross head	2585ft
Average annual variation in reservoir level	6·5ft
Maximum draw down	17ft
Estimated date when reservoir will have filled	June 1, 1957
Catchment area (excluding Nanika-Kidprice)...	5475 square miles
Reservoir area	358 square miles

were obtained by evaluating the value of power loss due to friction head against constructional cost, rate of interest and operating cost. This economic analysis resulted in the conclusion that twin 25ft diameter tunnels would be most economical, and possibly somewhat more reliable than a single 35ft diameter tunnel.

The invert of No. 1 power tunnel (which will be the north tunnel of the ultimate twin 25ft tunnels) will slope uniformly towards the surge shaft. Each tunnel will normally carry 3500 cusecs with a maximum of 4500 cusecs. The area of cross section is 527 square feet, the nominal volume of excavation per lineal foot 19·5 cubic yards, and the total volume of excavated rock, 23·0 cubic yards per lineal foot. There are four faces—east and west from a 1600ft adit near the mid-point of the tunnel length ; east from the surge chamber, and west from the intake end. The



Kenney Dam

Excavation of Power Tunnel in Bad Ground

illustration herewith shows excavation in progress at a point where the tunnel passed through bad ground, and steel supports were necessary; the position of the pilot tunnel may be noted. The second illustration of the tunnelling work shows the drilling jumbo in the power station tail-race tunnel.

Pressure Conduits

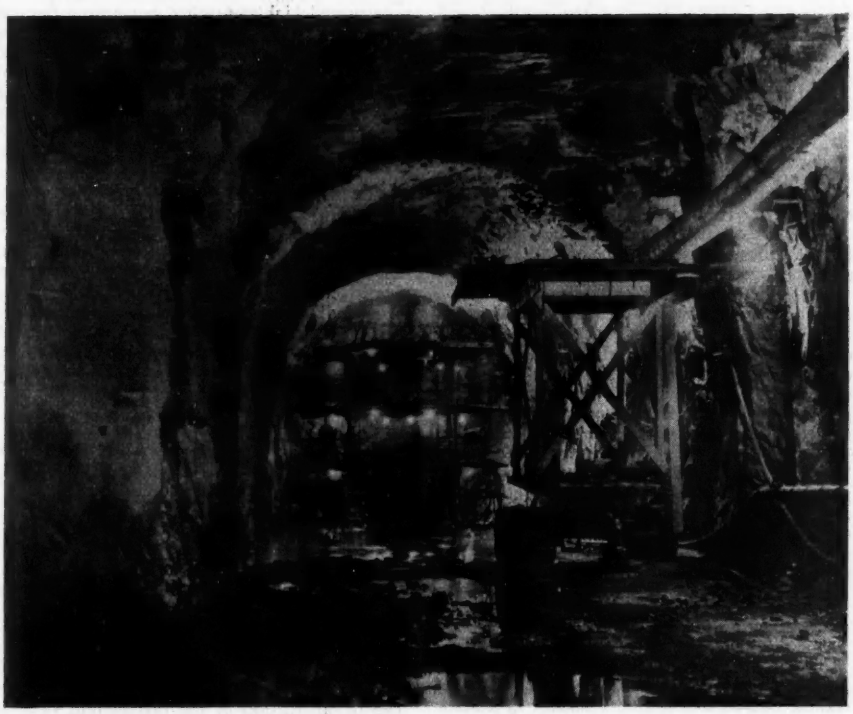
Downstream from the 25ft diameter power tunnel, the pressure conduit system for the first half of the ultimate sixteen-unit installation at Kemano will consist of a surge chamber and shaft followed by two 11ft diameter pressure conduits, branching from a steel wye, each controlled by an 11ft diameter oil-pressure-actuated butterfly valve about 300ft below the wye, with an air inlet valve below it. The conduits are each to be about 4000ft long, serving four units, excavated in the rock at an angle of 48 deg. to the horizontal.

The basic design of the pressure conduit involves the use of a steel lining to serve as a watertight diaphragm and as an inside form for the concrete backfill placed between the steel liner and the rock. Under operating conditions the hydrostatic pressure in the conduit will be carried partly by the steel and partly by the weight of the overlying rock. The concrete backfill and rock encasing the steel liner are to be thoroughly grouted to fill all voids and seams and consolidate the rock so that a reliable and uniform structure is secured.

At the lower end of the conduit, it branches symmetrically, to give four 5ft diameter pipes, each supplying one turbine. Spherical valves are to be installed in a valve chamber below the first branch. The normal operating head plus surge pressures will result in a maximum dynamic pressure at the manifold of the conduit of 1230 lb to 1236 lb per square inch (2836ft to 2850ft head). The internal pressure taken by the rock and concrete is taken as zero at the power-house and valve chamber openings, increasing gradually away from these points.

The properties of the rock through which the pressure conduits pass were investigated by means of a 10ft diameter test sphere encased in rock and concrete, and subjected to a test pressure of 3600 lb per square inch, virtually three times the pressure to which the pressure conduit will be subjected. Analysis of the test results show that an average modulus of elasticity of the rock at 1,500,000 lb per square inch could be taken, corresponding closely to the value predicted in advance of the test.

(*To be continued*)



Excavation of Tail-Race Tunnel, Kemano Power Station

Notes on Euler's Centrifugal Pump Theory

By D. B. WELBOURN, M.A.

That the characteristic curves of centrifugal fans and pumps show no sign of conforming to the simple Eulerian theory, even when corrected for inertia (relative eddy), suggests that some further and important fundamental point has been neglected; this point is simply that the Eulerian theory corrected for inertia would be true, if breakaway did not occur, for a pump or fan without a casing, since then and only then would the impeller determine the flow path so that efficient recovery of the velocity head could take place at all deliveries.

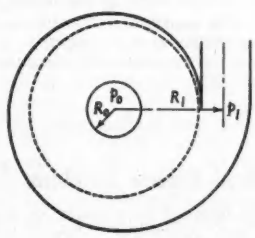
Consider a pump casing without an impeller as shown in the figure. If fluid flows from the outlet branch to the eye, then it can easily be shown that

$$p_1 = p_0 + \rho\frac{c^2}{2}\left(\frac{1}{R_1^2} - \frac{1}{R_0^2}\right) \quad . \quad . \quad . \quad . \quad (1)$$

where

p = static pressure.
ρ = density.
R = radius of any point on the casing.

This represents the only stable flow pattern through the empty casing, and consequently it remains true if the direction of flow is reversed so as to be from eye to outlet. If there is to be no pressure drop between inlet branch and outlet



branch, it implies that pre-whirl must automatically start to occur in the inlet branch some distance from the eye so as to provide the necessary whirl velocity there. The constant C in equation (i) is given by

$$C = V_t R, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where V_t = absolute tangential velocity at radius R.

The tangential velocity at the outlet V_{tR1} is directly proportional to the flow Q through the pump, and hence,

$$C = kQ, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

when k is a constant depending on the pump geometry.

For a given flow Q through the pump casing, whirl velocities must exist at all radii even without the action of an impeller; with an impeller rotating, however, it is possible for the water to flow radially from the eye of the impeller or in a free vortex determined by entry conditions.

It is instructive to write down what occurs on

simple Eulerian theory, neglecting the inertia term, and the same theory corrected for the presence of the casing. If the fluid has no initial moment of momentum, its absolute velocity at inlet being radial, it is shown in any textbook that the head imparted by the impeller is given by;

$$H_{Impeller}=\frac{1}{g}\left[u_2^2-\frac{Qu_2}{2\pi r_2 \tan\beta_2}\right], \quad . \quad (4)$$

where

Q=flow.
u_2=tip velocity of impeller.
r_2=tip radius of impeller.
β_2=tip outlet angle.

Now at radius r_2 the tangential velocity which would have to exist due to the casing is given by $k/r_2 \,.\, Q$, and only when the absolute tangential velocity at the exit from the impeller is equal to this natural casing flow velocity can the casing act as a perfect diffusor. If the tangential velocity is higher, head will be lost due to turbulent loss of velocity; if the tangential velocity is lower, then head must be lost to provide the minimum tangential velocity to enable the fluid to flow through the casing.

The flow for which the casing and impeller are perfectly matched, and no loss of head occurs, is given by:

$$\frac{k}{r_2}Q=u_2-\frac{Q}{2\pi r_2 \tan\beta_2}$$

$$\text{Therefore } Q=u_2\frac{r_2}{k+\frac{1}{2\pi\tan\beta_2}}. \quad . \quad . \quad . \quad (5)$$

The loss of head due to mismatching of casing, flow and impeller at any flow Q_1 is given by:

$$\text{Head lost}=\pm\frac{1}{2g}\left[u_2-\frac{Qu_2}{2\pi r_2\tan\beta_2}\right]^2 \mp\frac{1}{2g}\left[\frac{k}{r_2}Q\right]^2. \quad . \quad . \quad . \quad . \quad (6)$$

The complete expression for the head due to pump and casing is therefore:

$$H_{Pump}=\frac{1}{g}\left[u_2^2-\frac{Qu_2}{2\pi r_2\tan\beta_2}\right] -\frac{1}{2g}\left[\pm\left(u_2-\frac{Qu_2}{2\pi r_2\tan\beta_2}\right)^2\mp\left(\frac{k}{r_2}Q\right)^2\right] \quad . \quad (7)$$

Clearly, when $Q=0$, $W_{Pump}=u_2^2/2g$, which is more nearly in line with experience than is the classical Euler expression, and irrespective of whether the impeller blades are radial, swept backward or swept forward, the head flow curves will be parabolas. In practice, these parabolas will be accentuated due to a further term in Q^2 due to frictional loss being proportionate to the square of the flow velocity, but without this it is clear that this elementary consideration of the interaction of pump and casing is enough to account for the typical parabolic characteristics found in practice.

A Vertical Pinion Hobbing Machine

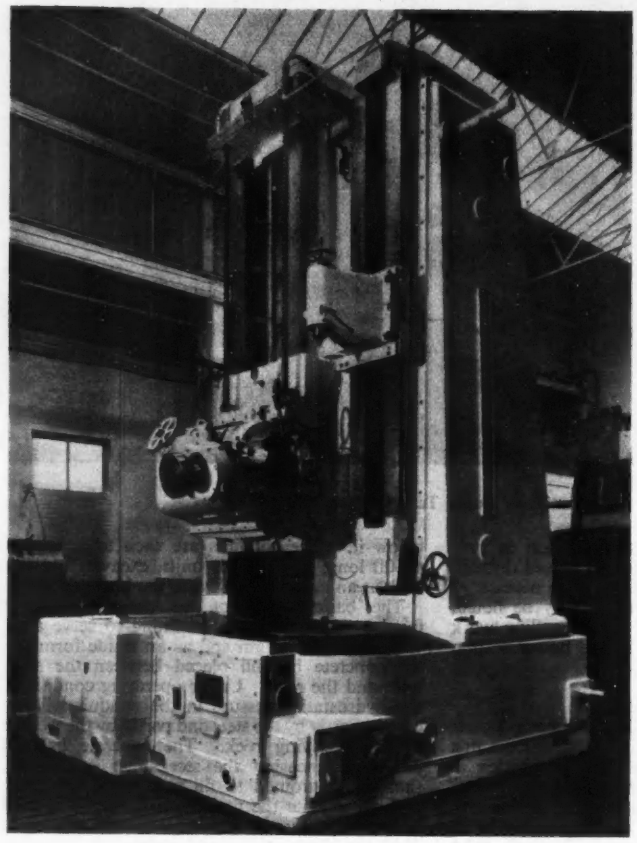
We have received from David Brown Machine Tools, Ltd., Sherborne Street, Manchester, particulars of a 36in vertical pinion hobbing machine which formed part of a consignment of gear cutting plant supplied recently to the Italian shipbuilding company of Ansaldo, Genoa.

This machine is the first vertical hobber of its size to be made by the firm and a photograph of it is reproduced herewith. It weighs about 60 tons and is designed to cut high-speed turbine pinions from 6in to 36in diameter at a maximum of 1¼ D.P. With an overall height of just under 20ft the machine can accommodate pinions with shafts up to 12ft long.

It is claimed by the makers that this departure from the conventional horizontal design of machine has several advantages, the most important being that it obviates the difficulty of obtaining true alignment due to the deflection of the pinion under its own weight.

As in other wheel hobbing machines, the axis of the table is vertical in the same plane as the upright carrying the hob slide, and this upright is widened to carry a work steady, the axis of which is in line with that of the table. By having the guides for the hob slide and pinion steady machined in the same plane on one cast-ing, accurate alignment between the two sets of guides is readily obtained.

Since the upright is fixed in relation to the axis of the table, alternative arrangements had to be made to compensate for variations in the diameters of gear blanks. This has been effected by providing separate vertical slides for the work steady and the hob saddle, in which an infeed hob slide is incorporated. The bed is a rigid box-section casting, housing the gearbox and table seating, whilst the upright, a well-ribbed casting, carries the vertical guides for the hob slide and steady.



36in Vertical Hobbing Machine

Vertical traverse of the hob slide is effected by a 5in diameter screw mounted centrally in the guideways and the range of vertical feeds is 0·007in to 0·100in per revolution of the table. The swivel slide pivots 45 deg. each way, enabling right and left-hand helical teeth to be cut. The hob spindle is 4in diameter and has a conical bearing at the hob drive end. It takes hobs up to 9in diameter and 12in long, and has a speed range from 12·5 to 58·5 r.p.m.

The solid table drive embodies a fine pitch dividing worm wheel, which is approximately 54in diameter or almost twice the diameter of the largest pinion cut on the machine. All driving gears to the dividing worm, vertical hob drive shafts, and lead screw are carried in the gearbox. The four motors of the machine are controlled from a central push-button station. The main motor of 10 h.p. gives speeds from 750 to 1500 r.p.m., and a 3 h.p. auxiliary motor provides for rapid traverse of the hob slide. A ¾ h.p. motor drives the automatic lubrication system and a 1 h.p. motor is used to drive the pump which supplies a continuous flow of cutting lubricant.

A Wrench Comparator Chart.—A chart has been published by Jenks Brothers, Ltd., Bushbury, Wolverhampton, to assist the selection of the correct wrench to suit any of the many standards of hexagonal nuts now in effect. This chart shows where one wrench opening can be common to a number of different standards of hexagon—for instance, many unified hexagon sizes are interchangeable with American, S.A.E., U.S.S., &c., whilst B.S.F. and Whitworth are similar.

Continental Engineering News

(By Our Continental Correspondent)

"Rotterdam City," Strasbourg

A "city" of some 800 dwellings has recently been erected in Strasbourg, situated by the Rue de Rotterdam, and hence called Cité Rotterdam. The entire project was studied, planned, built and completed in fifteen months. The site comprises eleven buildings, the tallest of thirteen storeys height, and the others of varying height down to one single-storey building. There are, in all, 806 flats in these eleven buildings, of seven different kinds, with floor areas from 240 to 1000 square feet. The project was completed three months ahead of the scheduled time, following the close co-operation between the technical services of the French Ministry of Reconstruction and Town Planning (M.R.U.), the chief architect, Monsieur E. Beaudouin and the contractors. During certain months a rate of construction of 140,000 square feet of flooring was maintained. The total cost of the project amounted to some 1300 million French francs (about £700,000).

Bridge Over the Ticino River, Italy

The River Ticino, near Turbigo, Lombardy, was before the war crossed by a steel lattice truss bridge, built about a half-century ago. The bridge was designed to carry both railway and highway traffic, but during the war it was practically destroyed. For various reasons, reconstruction work started only in 1952 and the bridge was officially opened by the Italian Minister of Public Works last February. The new structure is a steel lattice truss bridge, with three spans, respectively 144ft, 182ft and 147ft long. The piers of the pre-war bridge were repaired and are used to carry the superstructure of the new one. The lower decking accommodates a roadway 21½ft wide and two cantilevered footpaths, each 4ft wide. The upper decking is for single-track railway traffic. The main trusses are 25ft apart; they are of box-shaped cross section, 15in wide and 23ft high. The wind bracing consists of horizontal beams, placed between lower chords of the main girders. The Turbigo bridge was built by the Officine Bossi.

Railway Development in Belgium

The Belgian National Railways has prepared a programme of works, involving expenditure of some 4000 million Belgian francs (£28½ million) during 1953. Nearly half of this amount is to be spent on the renewal of track and structures, and over 1,000,000 francs is to be spent on electrification, including work on the conversion to electric traction of the lines Brussels–Ghent, Ghent–Ostend and Brussels–Louvain. Many terminal buildings will be enlarged and modernised as part of the programme, which also includes the restoration of several bridges damaged during the last war. The reconstruction of the marshalling yards at Monceau, Courtrai and St. Ghislain will be continued.

Industrial and Labour Notes

Britain's Overseas Trade

The trade and navigation accounts published by the Board of Trade last week confirm that the exports of United Kingdom goods in April were valued at £214,800,000, which was 3 per cent above the monthly average in the first quarter of the year and £1,700,000 higher than the monthly average in the fourth quarter of last year. The Board of Trade has pointed out that this result was achieved despite the loss of two working days in April, on account of the Easter holiday, and says that, if allowance is made for this, the daily rate of export in April was the highest for a year. All the increase in the month, compared with the first quarter of this year, was in exports of manufactured goods.

Among manufactures, exports of metals during April were £1,000,000 less than the monthly average for the first quarter, but shipments of engineering products increased by £6,000,000. It is stated that this increase in exports of engineering goods was brought about mainly by a rise of £4,000,000 in the value of vehicles exported. Of that sum, £1,000,000 was accounted for by bigger exports of passenger cars, all to Canada, and £2,000,000 by an increased tonnage of steam and motor ships, principally to Norway. There were also useful increases in exports of agricultural tractors, largely to Western European countries, and of locomotives and aircraft. Exports of machinery accounted for the remainder of the improvement in engineering exports generally, the main increases in April over the first quarter average being in shipments of electric generating sets and of agricultural machinery, especially combine-harvesters. The Board of Trade comments that there were substantial increases in machinery exports to South Africa and Canada and, to a smaller extent, to India and France. There was, however, some decline in April in exports of electric cables. The decline in exports of metals in April was accounted for principally by lower shipments of iron and steel, which was particularly noteworthy in exports to Australia, New Zealand and the British West Indies; there was, however, an increase of 60 per cent or so in iron and steel shipments to Canada, following the seasonally low level of the winter months. The Board of Trade says that all the decrease in iron and steel exports can be accounted for by reduced shipments of tinplate at a somewhat lower price; exports of wrought tubes and of railway material showed some compensating increase. Nearly half the decline in non-ferrous metal exports in April was due to a fall of approximately 30 per cent in shipments of tin, as compared with the preceding three months. Exports of aluminium were maintained but there was some further decline in exports of brass.

The recorded value of imports in April was £293,300,000, compared with a monthly average of £272,400,000 in the first quarter of the year. The volume of imports has been estimated provisionally as 10 per cent greater than the monthly average in the first quarter. The value of re-exports in April was £8,900,000, so that the excess of imports over total exports was £69,500,000. The average monthly deficit over the first four months of this year was £57,600,00.

European Steel Exports

The United Nations Economic Commission for Europe has issued a report, entitled *European Steel Exports and Steel Demand in Non-European Countries*, which emphasises the importance of iron and steel exports to the Western European economy as a whole. It reviews the history of the European steel trade over the past twenty-five years, and suggests that Western European steel exporters—who enjoy from 60 to 80 per cent of the world trade in steel—will have to modify their price and market policies in order to maintain and increase demand.

A special section of this report presents data on production, exports, imports and consumption of the main groups of steel products in thirty-seven non-European countries. The report also contains information about iron ore, energy resources, the steel industry and production plans in forty-two non-European countries. It is stated that in the last two years not much competition has been encountered in the world steel market but it is suggested that that situation is rapidly changing and that Europe's ability to maintain or improve its present position in the world steel markets depends essentially on its ability to produce steel of proper quality at low cost. "The profound changes in the organisational structure of a large part of the Western European coal and steel industries," the report observes, "present at least an opportunity to tackle many of the problems which international collaboration has so far been powerless to solve. If this opportunity is taken, it is not unduly optimistic to believe that Europe will again, as before the war, be able to supply 80 per cent or more of the import requirements of Africa, Asia and Latin America."

The report makes several suggestions to Western European steel exporting countries. They include the following: to offer stable supplies, particularly to regular customers, by being prepared to meet home and maximum foreign requirements and by offering long-term contracts; to reduce production costs "by various means," to charge reasonable and stable prices based on production costs; to discourage speculative stocking and dumping and the disruption of the market by unnecessary intermediaries; to provide credit and payment facilities when necessary; to improve sales organisations and expand technical help to customers in the utilisation of their products, and to foster economic development in the less developed countries. Referring to the importance of overseas investment, the report observes that the economies of under-developed countries depend mainly on the level of demand for their primary products by industrialised countries.

Engineering Wages

After a meeting of the general council of the Confederation of Shipbuilding and Engineering Unions, which was held at York on Wednesday of last week, it was stated that, by a large majority, it was decided to put forward a claim for a wage increase of 15 per cent. The council considered that the increase should be related to the wages of all grades of male manual workers in the shipbuilding and engineering industries and should be calculated on the consolidated time rate of pay.

It is understood that the claim has been submitted to the Engineering and Allied Employers National Federation and to the Shipbuilding Employers Federation. If granted, it would mean an increase of about £1 a week for skilled men and 17s. 6d. a week for unskilled. A year ago, it will be recalled, the Confederation sought an all-round increase of £2 a week for the members of the unions affiliated to it. After protracted negotiations, increases of 7s. 4d. a week for engineering workers and 7s. 6d. a week for shipbuilding workers were granted in November.

Manpower and Rising Costs

In the course of his chairman's statement, presented at the annual meeting of the Bristol Aeroplane Company, Ltd., which was held on May 21st, Sir William Verdon Smith made reference to the problem of skilled manpower and to the rising costs of production in the engineering industry. After mentioning the efforts being made by his company to obtain skilled men, Sir William said that the increase in the number of them was far too slow. The search for skilled men, he continued, was only part of a national problem. In his view, Sir William declared, we lived by our skill and not merely by increased productivity. Employers and employed alike had a responsibility to raise the proportion of skill in the factories far higher than it was to-day.

About the rising costs of production, Sir William expressed anxiety. Whether, he said, it was the basic rates of pay in the engineering industry itself, or the ever-rising costs of the services on which the industry depended, it could not earn, in the competitive markets of to-day, a major share of the country's bread and butter if costs were constantly forced higher and higher. The time had come, Sir William thought, for much wider realisation of that fact and for the exercise of the restraint which commonsense demanded. He went on to say that the availability of technical resources and plant, the search for skill and the need for stability in costs were all familiar themes. But each was vital to achievement and none could be too often stressed. There was a great task ahead, Sir William declared, and there were many risks inherent in it, but there was also a great opportunity.

The Road Haulage Disposal Board

On Thursday of last week the Minister of Transport, Mr. Lennox-Boyd, announced the appointments which he has made to the Road Haulage Disposal Board which is being set up under the Transport Act, 1953. Sir Malcolm Trustram Eve is the chairman of the Board, and Mr. F. J. Orchin, the deputy chairman. The other members are Lord Rusholme, nominated by the British Transport Commission; Mr. W. Gordon Graham, representing trade and industry; Mr. F. H. Farmer, representing holders of "A" or "B" carriers' licences, and Mr. J. W. Greenwood, representing holders of "C" carriers' licences.

In making his announcement, the Minister of Transport said that the chairman and members would serve on a part-time basis and the deputy chairman on a full-time basis. The salaries of the chairman and deputy chairman would be £3000 a year each, and Mr. Graham and Mr. Greenwood would each receive £500 a year, the other two members being unpaid. The Minister stated also that Lord Bilsland had agreed to make himself available for consultation on all questions involving Scottish interests.

Machinery Export Contracts

A panel of experts sponsored by the United Nations Economic Commission for Europe has just completed a set of model clauses for European plant and machinery export contracts. It is felt that the use of these model clauses, which take into account the view of both importers and exporters, should contribute to greater goodwill between buyers and sellers and make negotiation easier.

The model clauses have been incorporated in a publication entitled *General Conditions for the Supply of Plant and Machinery for Export*. The conditions, which may be used on a permissive basis, concern the following: formation of contract, drawings and descriptive documents, packing, inspection and tests, passing of risk, delivery, payment, guarantee, reliefs, limitation of damages, rights at termination, and arbitration and law applicable. There is also a supplementary clause on price revision.

The European Coal and Steel Community

The High Authority of the European Coal and Steel Community has now published its first report. It records the activities of the Community from the date of its establishment, August 10, 1952, to April 12th last. An accompanying document is a special report, which has also been prepared by the Authority, dealing with the establishment of the common market for steel. In both documents there are details of the measures so far taken by the Authority. In an introduction to its main report, the Authority says that the first stages in the establishment of the common market have been completed smoothly. The general aims are stated as being "to ensure the most rational methods of production at lowest possible prices, free access for all consumers to all sources of production, and the improvement of living conditions throughout the community."

Notes and Memoranda

Rail and Road

INSTITUTE OF TRANSPORT.—The council of the Institute of Transport has elected Mr. John Elliot to succeed Mr. C. T. Brunner as president. Mr. Elliot, who is the chairman of the Railway Executive, was elected a member of the Institute of Transport in 1938.

TRANSPORT HISTORY.—The first edition of a new publication entitled *The Journal of Transport History* has been published by the University College of Leicester. The object of this journal is to stimulate original research into the history of transport, review transport as a whole, and to provide a common ground for professional historians and transport men. This first edition contains the following articles :—" Workmen's Fares in South London, 1860–1914," by H. J. Dyos ; " The Balaklava Railway," by M. Robbins, and " James Green as a Canal Engineer," by C. Hadfield. The journal is to be published twice a year in May and November at 10s. net per copy and it can be obtained from University College, University Road, Leicester.

Air and Water

BOURNEMOUTH AIRPORT.—The Ministry of Civil Aviation has decided to alter the name of Hurn Airport to Bournemouth (Hurn) Airport, with effect from June 1, 1953.

ELECTRIC SALINOMETERS AND DENSOMETERS.—We have received from W. Crockatt and Sons Ltd., a copy of the new edition of the company's booklet describing the various designs of patent electric salinometers and densometers, manufactured by the firm, which give a reading, of reasonable accuracy, as low as 0·01 grains of chlorine per gallon in the feed water.

NEW AIR SERVICES APPROVED.—The Minister of Civil Aviation has approved the operation of a number of air services. A number of internal air services to Weston-super-Mare will be operated by the Don Everall (Aviation), Ltd and Cambrian Air Services, Ltd. A normal scheduled service on the route London-Rome-Cairo-Khartoum-Entebbe-Nairobi-Lusaka, and later, Salisbury, will be operated by British Overseas Airways Corporation until December 1, 1959, together with three services a week through Cyprus (Nicosia) on existing Corporation routes between the United Kingdom and the East. An all-freight service on the route London-Nicosia - Tripoli (Lebanon) - Kukuk - Baghdad - Basra - Kuwait-Dhahran-Bahrein-Dukham and/or Jebal Ali via technical stops at Nice, Malta or Rome, and Mersah Matruh or Athens will be operated by Airwork, Ltd., until March 31, 1960. The extension to Las Palmas until December, 1955, of Aquila Airway's Flying Boat service between Southampton and Madeira has also been granted.

Miscellanea

OIL DRILLING IN NOTTINGHAMSHIRE.—At Screveton, south of Newark, a rig is in course of erection for the purpose of drilling an exploratory well to a depth of 3500ft.

THE MONOPOLIES COMMISSION.—The Board of Trade states that Sir Arnold Plant has been appointed a part-time member of the Monopolies and Restrictive Practices Commission. Sir Arnold is head of the business administration department of the London School of Economics.

ECONOMIC PROSPECTS.—H.M. Stationery Office has recently published a booklet entitled *Britain's Way Ahead*, which briefly describes the problems emphasised by this year's Economic Survey and the contribution of the Budget to their solution. The booklet has been prepared by the Treasury and the Central Office of Information.

INSTITUTE OF TRANSPORT.—During the annual Congress of the Institute of Transport, to be held in Glasgow in July, members will have the opportunity of inspecting the Grangemouth refinery of the Anglo-Iranian Oil Company, Ltd., of making a flight over Finnart, the ocean terminal for Grangemouth, and of visiting one of the shale mines operated by Scottish Oils, Ltd.

NATIONAL DIPLOMA OF AGRICULTURAL ENGINEERING.—The regulations and syllabus of the examination for the National Diploma in Agricultural Engineering are now available from the Institution of British Agricultural Engineers, 24, Portland Place, London, W.1. They apply to the 1954 and subsequent annual examinations. The 1954 examination will begin on Tuesday, July 20th.

INDUSTRIAL ART BURSARIES.—The Royal Society of Arts has published a report on the industrial art bursaries competitions which it carried through in 1952, and has issued particulars of this year's competition. Prizes, amounting in all to £2250, take the form of travelling bursaries of £150 each, the competition being open to students who intend to take up industrial designing as a career. Full details of the competition are available from the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2.

HEAT-TREATMENT PRACTICE.—The British Iron and Steel Research Association is organising a conference on " Heat-Treatment Practice," which is to be held at Ashorne Hill, Leamington Spa, on Monday, Tuesday and Wednesday, June 15th, 16th and 17th. At the various sessions the following aspects of the subject are to be discussed :—The heat-treatment of engineering steels ; the heat-treatment of large forgings ; the heat-treatment of surfaces ; surface treatments ; isothermal heat-treatment, and temperature measurement and control. The chairman of the conference is to be Dr. H. H. Burton.

CENSUS OF PRODUCTION, 1950.—The first sections of the Census of Production for 1950 were published last week by H.M. Stationery Office. They are entitled *Introductory Notes* (price 1s.) and *Engineering, Shipbuilding and Electrical Goods, Vol.* 4 (price 2s.). It is announced that the report on the census for 1950 will contain separate particulars of 151 trades, in twelve volumes.

THE ROBERT WARNER FELLOWSHIP.—The Worshipful Company of Founders has announced the award of a Robert Warner Fellowship to Mr. J. H. Gittus, a member of the staff of the British Cast Iron Research Association. The Company is responsible for administering a trust fund, left by its former Master, Mr. Robert Warner, for providing fellowships to foster research applied to foundry practice.

STUDENTSHIP IN OCEANOGRAPHY AND LIMNOLOGY.—The council of the Royal Society has appointed Mr. A. S. Laughton, of King's College, Cambridge, to a John Murray travelling studentship in oceanography and limnology. Mr. Laughton is to undertake research on the physical properties of sediments, part of the work being carried out at the Lamont Geological Observatory, Columbia University, New York, in 1954.

ZINC PREMIUMS.—The Ministry of Materials has announced that, with effect from May 21st, the premium for 99·95 per cent grade zinc has been increased from £4 to £6 per ton, and the premium for 99·99 per cent grade zinc has been increased from £6 per ton to £9 per ton, for sales of zinc by the Ministry. It is stated that the Ministry's intention is to alter the premiums it charges according to the premiums currently fixed by the producers.

STANLOW REFINERY.—At present under construction at the Stanlow refinery of the Shell Petroleum Company, Ltd., is a " platformer " unit, which is the first to be built in Great Britain. The plant consists of three sections, namely, fuel preparation, reaction and stabilisation to produce components for blending into high-octane aviation spirit. The name of the unit, " platformer," derives from the fact that a platinum catalyst is used to reform low-grade into high-grade petrol.

" COMBINED FIRING AT ST. PANCRAS POWER STATION." —In the article on " Combined Firing at St. Pancras Power Station " we made the following mis-statement in the penultimate paragraph (page 497) : " Concurrently there has been a fall in the fuel cost per unit sent out and in the efficiency. . . ." The facts are that the station thermal efficiency has been raised by over 2 per cent, while concurrently—and contrary to expectations—there has been a fall in the fuel cost per unit sent out.

WELDING DESIGN BROCHURES.—Two new publications have now been added to the series of design brochures on welded structures issued by the Quasi-Arc Company, Ltd., Bilston, Staffs, as part of its service to designers and draughtsmen. The first of these new brochures, " Welded Plate Girders," deals with the design considerations of the component parts of welded plate girders, their fabrication and other practical factors involved. In addition, the complete design of a 30ft plate girder is given in detail, considered from the point of view of economy in cost and material. The second brochure, " Portal Frame Formulæ," gives a series of simple formulæ to enable the designer to deal with all kinds of single-bay, single-storey portal frames without having a detailed knowledge of the theory of rigid frame analysis.

COURSE ON GEOCHEMICAL PROSPECTING.—An introductory course of lectures and demonstrations of applied geochemical techniques is to be given at the Royal School of Mines, South Kensington, S.W.7, during the latter part of September next. The aim of the course is to provide a general background in geochemical prospecting necessary to an appreciation of the problems involved, and for the recognition of appropriate conditions under which the methods may usefully be employed. The course will be conducted by experts with practical experience in field and laboratory procedures, and it is expected that a leading American authority will take a prominent part in presenting the analytical aspects of geochemical prospecting. The fee for the course, which will last seven to ten days, will depend on the numbers attending, but will not exceed ten guineas. In order to facilitate the necessary preparations, inquiries should be addressed as soon as possible to Dr. J. S. Webb, Mining Geology Department, Royal School of Mines, London, S.W.7.

GALE-BLOWN TIMBER FOR PIT PROPS.—The gales last January caused major damage to trees in forest areas of North-Eastern Scotland, and it has been estimated that 40,000,000 cubic feet of standing timber was blown down. Nearly a third of this timber can be used as pit props and for other mining purposes, and the National Coal Board has made arrangements to take delivery of it over the next two years in addition to normal Scottish production. As this amount of timber—12,500,000 cubic feet—represents about twice the normal Scottish production of pitwood each year, men and machinery will have to be diverted to the devastated area from other forest districts. Under a special long-term price agreement with the Home Timber Merchants' Association of Scotland some of the timber will go to Scottish collieries. The balance, under a second agreement with the Association, will be supplied to collieries in England and Wales. The Government has agreed to afford some assistance to meet the abnormal transport costs involved. Less pit timber will be bought from abroad because of the larger quantities of Scottish wood that will be available under these arrangements.

SCIENTIFIC ADVISORY COUNCIL.—The Ministry of Supply announces that Professor Sir Eric Rideal, F.R.S., is to be chairman of the Minister's Advisory Council on Scientific Research and Technical Development in succession to Professor Sir John Lennard-Jones, F.R.S. Sir Eric Rideal, who is Professor of Physical Chemistry at King's College, London, has been associated with research work of the Ministry of Supply since the early part of the last war. Sir John Lennard-Jones has been chairman of the Advisory Council since 1947. He was recently appointed Principal of the University College of North Staffordshire.

THE WORK OF BRYAN DONKIN.—We have received from the Bryan Donkin Company, Ltd., Chesterfield, Derbyshire, a volume commemorating the firm's 150th anniversary. Much of this volume is devoted to a historical description of the work of Bryan Donkin, the firm's founder. Donkin's development of the first practical paper-making machine is described, as are many other engineering activities which he undertook at the firm's first works at Bermondsey. Donkin invented the steel pen nib, and he was the first to be successful in preserving food and fruit by canning ; he also developed a mercury tachometer. The engineering plant and equipment made by the firm under his guidance was extensive and varied, and included, to give one example, a waterwheel 76ft in diameter. All of these activities, together with an account of the Bryan Donkin Company as it is to-day, are described in the commemoration volume.

Personal and Business

MR. T. G. HICKS has been appointed joint managing director of Power Jets (Research and Development), Ltd.

MR. L. PEMBERTON has been appointed chief technical representative of Sanders and Forster, Ltd., Hertford Road, Barking, Essex.

THE HYMATIC ENGINEERING COMPANY, Ltd., Redditch, announces the appointment of Mr. G. V. Bloomfield as senior development engineer.

BRITISH UNITED TRACTION, Ltd., announces the formation of a new division to handle the design, development and marketing of diesel train units and components.

ELLIOTT BROTHERS (LONDON), Ltd., states that its Newcastle branch office has been moved to 36, Scottwood Road, Newcastle upon Tyne (telephone, Newcastle 23811).

THE MINISTRY OF SUPPLY announces that Mr. G. W. H. Gardner has been appointed Director General of Technical Development (Air) in succession to Mr. S. Scott Hall.

MR. SYDNEY PLAYER has resigned from the chairmanship of M. T. E. Control Gear, Ltd., Leigh-on-Sea, He continues as chairman of the Newall group of companies.

WILLIAM DOXFORD AND SONS, Ltd., states that Mr. Clement Stephenson, the general manager of the shipbuilding department since 1950, has been appointed a director of the company.

SPENCER-BONECOURT, Ltd., announces the retirement of Mr. W. Hawkins, chief erection and service engineer, after thirty-three years' service. Mr. B. D. Clark has been appointed to succeed him.

LIEUT.-COLONEL T. CHILD, M.I.Mech.E., has been appointed a director of British Engineers Small Tools and Equipment Company, Ltd., Buckingham House, Buckingham Street, London, W.C.2.

LAYCOCK ENGINEERING, Ltd., Sheffield, states that Mr. W. E. Thompson, secretary, has been appointed a director. Mr. Kenneth Walker, assistant production engineer, has been appointed works director.

MR. G. H. M. ROSAM, overseas manager of Parnall (Yate), Ltd., has been elected chairman of the Institute of Packaging. Mr. A. F. Cowan, of the Metal Box Company, Ltd., has been elected vice-chairman.

F. BODE AND SON, Ltd., Buxton Road, Leek, states that its welding positioners, hitherto marketed by Donald Ross and Partners, Ltd., are now sold direct to users. Mr. E. Courtney has been appointed sales manager.

HOOVER, Ltd., announces the appointment of Mr. W. A. Rigby as Northern divisional sales manager in the industrial products department, with headquarters in Manchester. Mr. A. R. H. Barton has been appointed Southern divisional sales manager, with headquarters at Perivale.

THE CUNARD STEAMSHIP COMPANY, Ltd., announces that Colonel Denis H. Bates has been elected chairman in succession to Mr. Frederick Alan Bates, who has held that office for the last seven years, and that Mr. William Donald, Mr. John A. Holt and Mr. John A. Brocklebank have been appointed deputy chairmen.

BROOK MOTORS, Ltd., Huddersfield, announces the retirement, on account of ill-health, of Mr. C. W. Scatcherd, manager of the Glasgow sales office. Mr. A. Wadsworth, manager of the Plymouth office, has been appointed to succeed him. Mr. J. D. Bailey, of the Birmingham office, will succeed Mr. Wadsworth, and Mr. F. Shaw, from the Huddersfield sales staff, is transferring to Birmingham.

Contracts

VICKERS-ARMSTRONGS, Ltd., announces the receipt of a repeat order for two cargo ships of 7800 tons from Alfred Holt and Co. ; both ships will be built at the company's Naval Yard at Newcastle upon Tyne.

British Patent Specifications

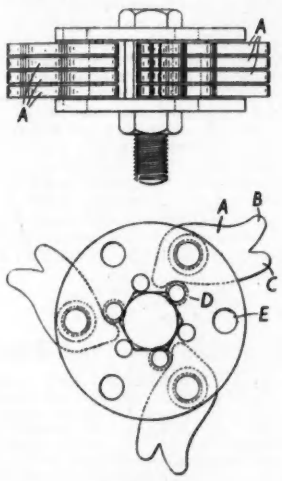
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

TOOLS AND WORKSHOP APPLIANCES

691,155. May 28, 1951.—DESCALING HEADS, Alva Ernest Hernandez, Grosvenor Gardens House, London, S.W.1.

The descaling head shown has three sets of chipping members *A*, each provided with its own pivot pin supporting it between two end plates. A bolt, adapted for connection to a driving shaft, is passed through



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the end plates. Each chipping member has at its operative end two projections *B* and *C*, of which *B* first engages the work. When this projection becomes partly worn, the two projections engage the work simultaneously. The pivotal movement of each chipping member is limited by a bolt *D*. Spare holes *E* may be provided for the pivot pins, and spare holes for the bolts *D*.—*May* 6, 1953.

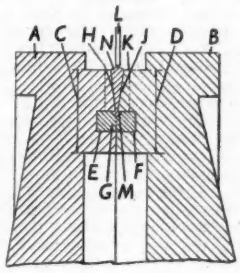
METALLURGY

690,374. November 14, 1947.—METHODS OF DEPHOSPHORISING BASIC BESSEMER STEEL, Société Anonyme des Hauts-Fourneaux de la Chiers, Longwy (Meurthe-et-Moselle), France.

The invention consists in adding caustic soda in the converter itself at or near the end of the converting operation by various procedures. After completion of the normal air blowing operation, swinging down the converter and the slag, the caustic soda is introduced through the nozzle of the converter on to the surface of the metal bath, then the converter is swung up again while a blast of air is discharged for some fifteen to twenty seconds, sufficient to ensure a vigorous mixing of the reagent with the bath of metal. The reagent may also be added during the blast period, towards the end of the decarburising period. For this purpose a hopper is used, arranged above the converter, and the addition is effected without interrupting or even slowing down the blast, simply by inclining the converter so that its nozzle underlies the hopper. After the reagent has been introduced the converter is turned back to its normal position. The amount of reagent used is relatively small by weight, being more specifically in the range of from 1·5kg to 3·5kg of caustic soda per ton of steel. The reaction, which is practically instantaneous, results in bringing down the phosphorus content from about 0·06 per cent to a very much lower value, which may be as low as 0·02 per cent. Furthermore, it is accompanied by a considerable deoxidising action of the order of 40 per cent, the oxygen content in the liquid steel being reduced from about 0·095 per cent to about 0·058 per cent, as measured by the Herthy bomb method.—*April* 22, 1953.

690,562. May 30, 1950.—METHODS OF FUSION WELDING, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6, and Denis George Sinfield, of the company's address.

The invention relates to methods for fusion welding together the discs of gas and steam turbine rotors. In the drawing rim portions *A* and *B* of two discs to be welded together are provided with portions *C* and *D* between which the joint is made. Recesses *E* and *F* are cut into each portion to form flux channel *G* below the areas *H* and *J* to be welded. One or more holes *K* are provided in portions *C* and *D*, to fill the flux channel *G* with welding flux. The channel *G* is annular and the joint between faces *H* and *J* is non-continuous, being interrupted by the holes *K*. Where holes *K* are used the flux is tamped into the flux channel and the first run of weld metal applied by a welding tool *L* forming a bead *M* on the underside of the joint, the consideration on packing the flux being that it will be sufficiently tightly packed so as to retain the weld metal in the form of a bead as shown. The rest of the welding operation builds up



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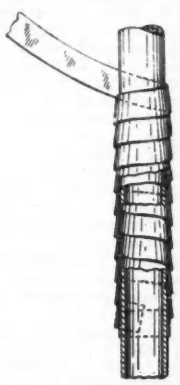
the weld bead *N* and can be done automatically or manually. The method lends itself to a completely automatic and continuous welding operation if, instead of admitting the flux through a series of holes *K*, the flux is fed into a continuous gap between faces *H* and *J* in communication with flux channel *G*. This gap and the shape and dimensions of the flux channel should be such that the flux feeding in, by gravity, say, simultaneously with the welding operation, will remove pockets of air in the channel and will effectively support the bead of weld *M*. In such a method the welding tool should be submerged in the continuous flow of flux into the flux channel *G*. The method of welding described can be applied to the joining together of high-pressure and high-temperature pipes.—*April* 22, 1953.

VIBRATION ABSORBERS

691,259. May 21, 1951.—DEVICES FOR DAMPING VIBRATIONS IN PIPES, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor: Frederick James Hardy.*)

This invention aims to provide a simple form of damping device for use in protecting pipes employed in connection with machinery, against fatigue failure due to induced vibration. A tubular spring element fitted over the pipe is formed from metal ribbon so wound on a mandrel that each turn of the ribbon partly overlaps the previous turn. The spring



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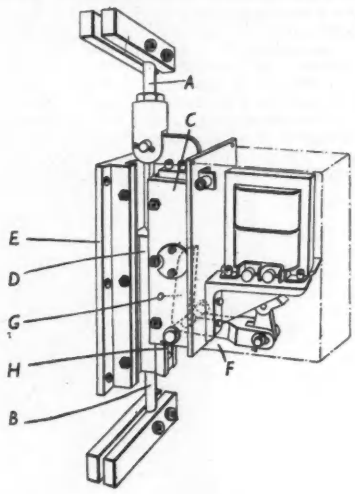
element may be formed with such an internal diameter in its free state that it is capable of being slipped over the pipe without increasing the free diameter of any of the coils or it may be arranged to grip the pipe. In the illustration a fuel pipe of an internal combustion engine is shown fitted with a damping device in the course of manufacture. Normally, the device would be wound on a mandrel.—*May* 6, 1953.

MACHINE TOOLS

691,066. June 8, 1951.—SAFETY DEVICE CONTROLLING A MACHINE CLUTCH, Radiovisor Parent-Ltd., 1, Stanhope Street, London, N.W.1; Goodwin Alfred George Ive, 220, Eden Park Avenue, Beckenham, Kent; Duple Motor Bodies, Ltd., Edgware Road, The Hyde, Hendon, London, N.W.9, and Alan Charles Hill, 5, The Close, Barnhill Road, Wembley, Middlesex.

It is the object of the invention to provide a clutch release mechanism which is controlled by the photo-electrically controlled guard of a press. A rod which usually connects the clutch of the press to a pedal is formed by two parts *A*, *B*, which are spaced apart to enable a release device to be fitted. To each of the rods is secured a member *C*, *D*. The member *C* secured to the rod part *A* is provided with a longitudinal guideway having a sliding reception for the member *D* secured to the rod *B*, which is connected to the pedal. The member *C* is secured to a solenoid which is electrically included in a photo-electric circuit controlling the clutch release mechanism of the press. The opposite face of the member *D* slides in a third member *E* which is fixed to the press. The member *C* has a longitudinal slot which is mounted on a pawl *F*. One arm *G* of the pawl is adapted to co-operate with a longitudinal recess *H* in the member *D*, whilst the second arm is connected to the armature



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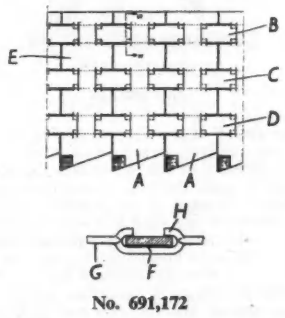
of the solenoid. When the solenoid is energised the arm *G* locks the two members *C* and *D* together. When the member *D* is pulled downwards by pressure on the pedal and the solenoid is energised, both members *C* and *D* move downwards as a unit to engage the clutch. When the solenoid is not supplied with current, the end of the recess *H*, as a result of the downward movement of the member *D*, rocks the pawl into the member *C* so that these members are disengaged, and the press is not operated. This condition arises, for example, when the pedal is depressed when part of the person of the operator interrupts the light curtain of the photo-electric guard.—*May* 6, 1953.

691,172. May 13, 1948.—BAND SAWS FOR SAWING STONE, Sonapar, Société de Participation, Société Anonyme, 15, Rue Guillaume Schneider (Grand Duché de Luxembourg).

The band saw described has a number of blades *A*, each with an oblique outer edge which forms the tooth. Preferably the cutting edges of the teeth are made of abrasive material, such as tungsten carbide or vanadium steel brazed to the teeth. The saw has three steel belts *B*, *C* and *D* to which are fastened the blades in such a way that they support one another and allow flexibility. To fasten the blades to the flexible steel belts or straps without using rivets, bolts or other means, each blade has loopholes of substantially the same width as the straps. The blade



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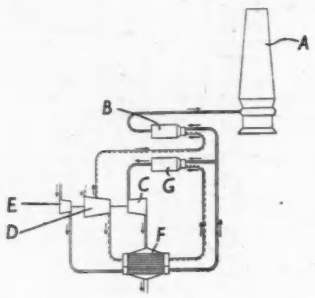
junction or bridge portions *E* are joggled so as to have their front faces *F* in the plane of the back face *G* of the blade so that the belts lie substantially in the plane of the blades. Portions on each side of the junction portions, and formed from the blade material, constitute hook-like lugs *H*. In making a complete saw, each blade is placed in contact with the blade on either side and the flexible straps are threaded through the pairs of loopholes between the junction

portions and the lugs. The lugs are then folded as shown in the lower drawing, so that the straps lie substantially in the plane of the blade.—*May* 6, 1953.

GAS TURBINES

690,427. October 21, 1949.—COMBINED GAS TURBINE AND INDUSTRIAL FURNACE PLANT, Maschinenfabrik Oerlikon, Oerlikon, near Zürich, Switzerland.

The drawing shows a blast-furnace *A* and a combustion chamber *B*, in which chamber, in place of a Cowper stove or a steel heat exchanger, the air of combustion for the blast-furnace is heated up to 750 deg. Cent. In consequence of the combustion in the chamber, hot gas enters the blast-furnace. The combustion chamber is so constructed that the burnt gas has a very large excess of air, so that sufficient air of combustion is available for the blast-furnace. *C* is a gas turbine, *D* an air compressor, and *E* a gas compressor. Air is withdrawn from an intermediate stage of the air compressor *D* and led to the combustion chamber *B* to serve as air for the combustion in it. The compressed air and the compressed gas are preheated in a heat exchanger *F* by the exhaust gases of the gas turbine and are led to the combustion chamber *G* of the turbine. Compressed gas



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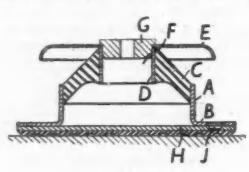
is likewise led to the combustion chamber. The combustion chamber *B*, it is stated, replaces the known Cowper stove and steel heat exchanger, it takes up less room, and the temperature for the blast-furnace can be regulated and adjusted to any desired level, if necessary, also above 750 deg. Cent. In a modification shown in the specification, instead of compressed air from the compressor, compressed gas which is derived from an intermediate stage of the gas turbine is led to the combustion chamber.—*April* 22, 1953.

BEARINGS AND SUPPORTS

690,443. October 14, 1950.—RESILIENT MOUNTINGS, Dunlop Rubber Company, Ltd., 1, Albany Street, London, N.W.1. (*Inventors: Robert Maxwell Seddon and George Henry Goulding.*)

As shown in the drawing, the mounting comprises a tubular metal member *A* having at one end a circular flange *B* extending outwards. Coaxial with the hole, a rubber annulus *C* of frusto-conical form is bonded at its major external diameter to the inside of the hole. Within the hole in the rubber annulus is bonded a metal sleeve *D* having an accurately machined bore. An annular dished cover plate *E* fits coaxially against



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the upper end *F* of the sleeve. A plug *G*, having a shank very slightly larger in diameter than the internal diameters of the sleeve and the cover plate is pressed through the hole in the cover plate, the plug collar retaining it in position. The shank extends somewhat less than half way into the bore of the sleeve and causes a slight increase in external diameter of that portion of the sleeve as it is forced into the bore. The expansion of the sleeve relieves tensile stresses induced in the rubber annulus between the rigid tubular member and the rigid sleeve on cooling after moulding, these stresses being locally intense in the rubber encircling the expanded portion of the sleeve on account of the axial tension induced in the rubber at the bonded interface. The flange on the tubular member is provided with three equally spaced holes and a circular base plate has three locating pegs, projecting to engage freely the holes in the flange. Moulded on the face of the base plate remote from the pegs is a facing or surface of natural rubber patterned with concentric grooves. In use the mounting is attached to the base of a machine by means of a bolt passing through a hole in the plug and the base plate contacts a floor, the rubber facing on the base plate providing a high frictional resistance to any tendency of movement of the machine as it vibrates. Two modifications are also shown in the specification.—*April* 22, 1953.

Technical Reports

Deterioration of Insulation by Electrochemical Agents: Moisture Detection by Tests at Very Low Frequencies (Ref. V/T105). By G. Mole, Ph.D., F.Inst.P., and D. C. G. Smith, B.Sc. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—A new method is examined in which the vector admittance of the insulation is measured over a range of low frequencies (0·18 c/s to 56 c/s) to yield the relation of the measured conductance G_m to the measured capacitance C_m. Moisture displaces the characteristic. If the position for the dry condition is known, moisture may thus be detected. In addition, there is some experimental evidence that the absolute slope of the characteristic may measure the moisture content. Results of tests are given on resin-bonded paper board, current transformers and bushings. The equipment is at present in experimental form, but is capable of development to meet requirements of portability and speed of use for testing insulation in the field.

Pest Control by High-Frequency Electric Fields: Critical Résumé (Ref. W/T23). By A. Morris Thomas, B.Sc., F.Inst.P., M.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 24s., postage 4d.—This résumé purports to be an authoritative statement on the use of high-frequency electric fields for pest control. It comprises an account of the relevant physical and mathematical theory with applications, parts of which are original, together with a review of the literature and some suggestions for further experimental investigation. It is concluded that the disinfestation of many kinds of grain, seeds and other foodstuffs can be effected by the application of h.f. electric fields, and that the method is capable of commercial exploitation. The indications are that pests are destroyed by this process, as a result of excessive temperature rise rather than any other specific effect. The frequencies used at present range from 1 Mc/s to about 100 Mc/s.

Flameproof Electrical Apparatus: Flanged Joints, One ¼in in Radial Breadth, in Mixtures of Acetone Vapour and Air (Ref. G/T274). By H. Robinson, J. T. W. Roper and H. L. Williams. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 10s. 6d., postage 3d.—For mixtures of acetone vapour and air exploded in an 8-litre bronze sphere (provided with smooth horizontal equatorial flanges, one ¼in in radial breadth), it is found that the most incendive mixture contains 5·2 per cent acetone vapour by volume. The most readily ignitible external mixture contains 6·8 per cent acetone vapour by volume.

The maximum experimental safe gap (M.E.S.G.) associated with this combination of internal and external mixtures, on a criterion of $n=20$, $k=0·001$in, is found to be 0·034in; and the statistical maximum safe gap, S.M.S.G.(R), calculated by the improved method recently adopted, to be 0·025in.

The effect on the maximum safe gaps, experimental and statistical, of reducing the flange breadth from 1in to one ¼in cannot be accurately assessed because of differences between the criteria adopted in the 1938 investigation which determined the data for 1in flanges (Ref. G/T110), and in this investigation. The safe gaps for 1in flanges are scheduled for re-determination in order to clarify the effect of the reduction in flange breadth. The tests were made at Buxton in co-operation with the S.M.R. Establishment of The Ministry of Fuel and Power.

The Ignition of Methane-Air Gas Mixtures by Capacitive Spark Discharges (Ref. G/T278). By H. G. Riddlestone, B.Sc. (Eng.), A.C.G.I., D.I.C. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—This report describes measurements on the minimum energy necessary for the ignition of methane-air gas mixtures by capacitive spark discharges.

The effects of circuit voltage, resistance and inductane on the incendivity of the discharge were determined with ignition apparatus described, and the corresponding electrical characteristics were measured using the technique and equipment described in Report Ref. G/T253.

The Use of Electricity to Increase Soil Temperature (Ref. W/T26). By E. W. Golding, M.Sc. Tech., M.I.E.E., Mem. A.I.E.E. The British Electrical and Allied Industries Research Association, Dorking Road, Leatherhead, Surrey. Price 9s., postage 3d.—Electrical methods of raising soil temperature are discussed under the two main headings of Soil Warming and Soil Sterilisation. Brief descriptions of the necessary techniques and equipment are given, but emphasis is laid upon the energy consumption for specified temperature rises, and on the temperature distribution in the soil, under conditions which occur both naturally and with different arrangements of the heating elements. The influence of temperature gradient upon the technique required for practical application by electrical methods is discussed. The researches of the Electrical Research Association on electrical soil warming and soil sterilisation are briefly described and some of the results obtained in these researches are given.

Measurement of Humidity. Notes on Applied Science, No. 4. By the National Physical Laboratory. London: H.M. Stationery Office, Kingsway, W.C.2. Price 1s.—This is one of the National Physical Laboratory's series of Notes on Applied Science and is intended to make available a simple description of the methods of measuring humidity and of the instruments used for this purpose, together with a review of the problems that might arise. The booklet is written for the non-specialist and contains no difficult technical detail so that the notes should prove of value to those having to measure humidity in day-to-day work. Physical principles are briefly stated and there are descriptions, together with drawings, of many designs of hygrometers, while instructions on the checking and calibration of the instruments are given. Appendices give definitions of technical terms, list reference tables and include a list of books and references which may be consulted for additional information.

Launches and Trial Trips

GENERAL MANGIN, passenger liner; built by the Société des Chantiers et Ateliers de Saint-Nazaire-Penhoet for the Compagnie Fraissinet; length between perpendiculars 492ft 2in, breadth moulded 64ft 10in, depth to upper deck 43ft 3in, load draught 22ft 9in; deadweight 5400 tons, load displacement 14,068 tons; service speed 16 knots, radius of action 7000 miles; passengers 942, including 132 first-class and 125 second-class; two Burmeister and Wain two-stroke, single-acting diesel engines, 8300 b.h.p. at 137 r.p.m.; two 405kW and one 305kW diesel generators. Trial, March.

CALTEX MANCHESTER, oil tanker; built by R. and W. Hawthorn, Leslie and Co., Ltd., for the Overseas Tankship (U.K.), Ltd.; length overall 544ft 4in, breadth moulded 70ft, depth moulded 39ft 9in, deadweight 17,450 tons, trial speed 15 knots; double reduction geared turbine, 8200 s.h.p., steam supplied at 450 lb per square inch and 750 deg. Fah. by two Yarrow three-drum boilers; two 400kW geared turbo-alternators. Launch, April 29th.

MIDDLESEX, refrigerated cargo ship; built by Alexander Stephen and Sons, Ltd., for the Federal Steam Navigation Company, Ltd.; length 469ft 6in, breadth 64ft 6in, depth 42ft, load draught 27ft 4in, gross tonnage 8230; seven water-tight bulkheads, five cargo holds 10-ton derricks and one of 50 tons capacity; two ten-cylinder Sulzer diesel engines, each developing 4500 s.h.p. at 225 r.p.m., engines geared to one shaft through B.T.H. magnetic couplings and gearing supplied by the Power Plant Company; four 300kW Ruston and Hornsby diesel-driven generators. Trial, April.

ALKAID, oil tanker; built by the Netherlands Dock and Shipbuilding Company, Amsterdam, for the Alvion Steamship Company, Ltd., Panama; length between perpendiculars 565ft 6in, breadth 76ft 6in, depth 42ft, summer draught 32ft ¾in, deadweight 24,000 tons; speed at 32,000 tons displacement 14·5 knots; N.D.S.M. Stork double-acting, two-stroke, diesel engine, seven cylinders, 7400 i.h.p. at 117 r.p.m.; one diesel-driven generator-compressor, 200kW, and 240 cubic metres of free air per minute, one steam-driven generator-compressor set of same capacity; two Scotch boilers. Launch, May 9th.

BRITTA, oil tanker; built by Harland and Wolff, Ltd., Govan, for Mr. A. H. Mathiesen, Oslo; length between perpendiculars 540ft, breadth moulded 73ft, depth moulded 39ft 3in, deadweight 18,500 tons; Harland and Wolff-B. and W. two-cycle, opposed piston engine, six cylinders, 750mm diameter by 2000mm combined stroke, 114 r.p.m.; two cylindrical multi-tubular boilers; one 100kW diesel-driven generator, two 75kW steam-driven generators. Launch, May 12th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ELECTRIC RAILWAY SOCIETY

Thurs., June 11th.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "Distant Dormitories," by G. T. Moody, 7.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Thurs., June 18th.—Visit to the works of the British Oxygen Company, Ltd., Cricklewood, N.W.2, for practical welding demonstrations, 2.30 p.m.